Please type a plus sign (+) inside this box → [+]

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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	500.31108CC4
Total Pages	76
First Named Inventor or Application Identifier	A. TANAKA et al.
Express Mail Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

1. [X] Fee: 1,282.00

Please charge any shortages in the fees or credit any over-payments therof to the deposit account of Antonelli, Terry, Stout & Kraus, Deposit Account No. 01-2135.

2. [X] Specification [Total Pages 34]
3. [X] Drawing(s) (35 USC 113) [Total Sheets 7]
4. Oath or Declaration [Total Pages 2]
   a. [ ] Newly executed (original or copy)
   b. [X] Copy from a prior application (37 CFR 1.63(d)) (for continuation/divisional with Box 17 completed) [Note Box 5 below]
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
5. [X] Incorporation By Reference (useable if Box 4b is checked) The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. [ ] Microfiche Computer Program (Appendix)
7. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. [ ] Assignment Papers (cover sheet & document(s))
9. [ ] 37 CFR 3.73(b) Statement (when there is an assignee) [ ] Power of Attorney
10. [ ] English Translation Document (if applicable)
11. [X] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
12. [X] Preliminary Amendment
13. [X] Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
14. [ ] Small Entity Statement(s) [ ] Statement filed in prior application, Status still proper and desired
15. [ ] Certified Copy of Priority Document(s) (if foreign priority is claimed)
16. [X] Other: Claim for Priority

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:
[X] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: 08 / 895,886

18. CORRESPONDENCE ADDRESS

[X] Customer Number or Bar Code Label 020457
(Insert Customer No. or Attach bar code label here)

11. SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

NAME	Carl J. Brundidge		
SIGNATURE			
DATE	September 29, 1998	REG. NO.	29,621

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500.31108CC4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	A. TANAKA et al.
Serial No.:	Not Yet Assigned
Filed:	Even Date Herewith
For:	DATA RECONSTRUCTION METHOD AND SYSTEM EMPLOYING THE SAME
Group:	2785 (Anticipated)
Examiner:	H. Nguyen (Anticipated)

PRELIMINARY AMENDMENT

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

September 29, 1998

Sir:

Prior to examination, please amend the above-identified Rule 53(b) continuation application submitted herewith as follows.

The additional claim fee of $492.00 due in connection with the filing of this preliminary amendment is included in the check attached to the accompanying utility patent application transmittal form.

IN THE TITLE

Please change the title to --DATA RECONSTRUCTION METHOD AND SYSTEM WHEREIN TIMING OF DATA RECONSTRUCTION IS CONTROLLED IN ACCORDANCE WITH CONDITIONS WHEN A FAILURE OCCURS--.

IN THE SPECIFICATION

Page 1, before line 1, insert the following new section:

--CROSS-REFERENCES TO RELATED APPLICATIONS

This is a continuation of application Serial No. 08/895,886 filed on July 17, 1997, which is a continuation of application Serial No. 08/534,841 filed on September 27, 1995, which is a continuation of application Serial No. 07/859,850 filed on March 30, 1992, now U.S. Patent No. 5,495,572.--;

lines 9-11, delete in their entirety insert --in parallel is disclosed in Japanese Kokai 1-250128 corresponding to U.S. Patent Application Serial No. 07/118,785 filed on November 6, 1987, now U.S. Patent No. 4,870,643, and Japanese Kokai 2-135555.--;

line 15, delete "striped" insert --divided--, delete "unit, byte unit" insert --units, byte units--;

line 16, delete "unit," insert --units,--;

line 21, delete "striped up" insert --divided--.

Page 3, line 1, delete "the" (second occurrence);

line 2, delete in its entirety insert --code and error check code (ECC) methods.--;

line 10, delete "inspite" insert --in spite--.

Page 4, line 15, delete "comprising:" insert --including--;

line 16, delete "striping" insert --dividing--;

line 17, delete "unit, bite unit" insert --units, byte units--;

line 18, delete "unit" insert --units--, delete "striped" insert --divided--;

line 20, delete "striped" insert --divided--;

line 23, delete "I/O" insert --an I/O operation--.

Page 5, line 15, delete "processing";

line 16, delete in its entirety insert --amount of the data reconstruction within a unit time.--;

line 27, delete "has a room for" insert --is less than--.

Page 6, line 6, delete "room in the" insert --remaining--;

line 10, delete "a room in the" insert --some remaining--;

line 12, delete "accumulating totals of";

line 13, delete "which was";

line 18, delete "the" insert --a--;

line 19, delete "the" (first occurrence), after "night" insert a comma;

line 22, delete "the" (third occurrence) insert --a--;

line 26, after "reconstruction" insert --within a unit time,--.

Page 8, line 11, delete the second comma;

line 12, delete "the";

line 21, delete "room" insert --remaining redundancy--.

Page 9, line 1, delete "room" insert --remaining redundancy--;

line 12, delete "it can proceed to the" insert --a--;

line 13, after "processing" insert --can be performed--;

line 19, delete "state." insert --state (Step 90).--;

line 21, delete "Steps" insert --steps--;

line 23, delete "the description will be given to";

line 25, delete "of" insert --will be described with reference to--;

line 28, delete "I/O" insert --an I/O operation--.

Page 10, line 2, delete "the" (second occurrence) insert --a--;

line 3, delete "is occurring" insert --has occurred--;

line 8, delete "reconstruction," insert --reconstruction within a unit time,--;

line 10, delete "that" insert --whether--;

line 12, after "range" insert a comma;

line 13, delete "the";

line 14, delete "getting" insert --which are entering--;

line 15, delete "into", delete "to monitor" insert --and monitors--;

line 18, delete "on referring" insert --below with respect--;

line 23, delete "with" insert --based on--;

line 27, delete "write" insert --writing--.

Page 11, line 5, delete "158 to" insert --158, 160, 162, 164, 166, and--;

line 7, delete "striped" insert --divided--, delete "the six" insert --six data--, delete "as the";

line 8, delete "data discs";

line 10, delete "the";

line 11, delete "striped six" insert --divided--, delete "discs 158 to" insert --six data discs 158, 160, 162, 164, 166, and--;

line 14, delete "data 158 to 168." insert --divided data stored in the six data discs 158, 160, 162, 164, 166, and 168.--;

line 15, delete "which the memory has" insert --of the memory--;

line 17, delete "the" (second occurrence);

line 18, delete in its entirety insert --more than a certain number of the discs break down,--;

line 19, delete "certain number,";

line 20, delete "the";

line 21, delete "even", delete "data" insert --discs--;

line 22, delete "i.e., the" insert --when--;

line 24, delete "the" (first occurrence) insert --an--, delete "stands up to" insert --can compensate for--;

line 26, delete "the" (first occurrence);

line 27, after "redundancy" insert a comma;

line 28, delete "Code." insert --code.--.

Page 12, line 1, delete "Code" insert --code--;

line 4, delete "units" insert --discs--;

line 6, delete "the" insert --a--, delete "unit," insert --disc,--;

line 7, delete "unit" insert --disc--;

line 8, delete "those discs" insert --spare storage discs--;

line 10, delete "description will now be given to the";

line 11, delete "fault." insert --fault will now be described with reference to Fig. 3.--;

line 16, delete "faulty data" insert --failure--;

line 22, delete "unit";

line 24, delete "to inform" insert --and informs--.

Page 13, line 5, delete "to" insert --in--;

line 8, delete "to" insert --in--;

line 11, delete "to" insert --in--;

line 13, delete "to" insert --in--;

line 15, delete "to" insert --in--, delete "address." insert --the sector or address of the failure.--;

line 19, delete "Step." insert --step.--;

line 20, delete "Step," insert --step,--;

line 26, delete "on referring" insert --below with reference--.

Page 14, line 3, delete "state." insert --state (Step 112).--;

line 5, delete "then, the above Steps" insert --and the above steps--;

line 6, delete "will be" insert --are--;

line 7, delete "Even if" insert --When--;

line 10, delete "the" (second occurrence) insert --a--;

line 15, delete "of" insert --for--, delete "in" insert --is--;

line 18, delete "the" (second occurrence) insert --a--;

line 22, delete "have" insert --be in--;

line 23, delete in its entirety insert --units, sector units, word units, or any other units.--;

line 24, delete "the description will be given to";

line 25, delete "on referring" insert --will be described with reference--;

line 27, delete "of" (second occurrence) insert --for--;

line 28, delete "is not" insert --has not been--.

Page 15, line 2, delete "the" (first occurrence) insert --a--;

line 3, after "than" insert --or equal to--;

line 5, delete "is a room" insert --some remaining--;

line 6, delete "in the";

line 7, after "preference" insert a comma;

line 13, delete "the redundancy has no room," insert --there is no remaining redundancy,--;

line 17, delete "with" insert --on the basis of--;

line 19, delete "for" insert --in--;

line 27, delete "the".

Page 16, line 7, delete "the" (first occurrence) insert --indicate--;

line 8, delete "the" (first occurrence) insert --indicate--;

line 10, delete "write of" insert --writing--;

line 11, delete "to" insert --which would normally--;

line 14, delete "the" (first occurrence) insert --indicate--;

line 18, delete "Code" insert --code--, delete "the multiplex dissipation" insert --errors in--;

line 19, delete "with", delete "have" insert --be--;

line 20, delete "integral" insert --integer--;

line 24, after "the" (second occurrence) insert --last--;

line 25, after "constructed" insert a comma, delete "at the last time,";

line 26, delete "performed" insert --continued--;

line 27, after "the" (second occurrence) insert --last--;

line 28, delete "at the last time".

Page 17, line 2, delete "154 and thus" insert --154, thus indicating that--;

line 4, delete "of" insert --at--;

line 9, delete "to" insert --in--;

line 10, delete "the" (second occurrence) insert --indicate--;

line 12, delete "will" insert --can--;

line 24, delete "for" insert --in a--;

line 25, delete "the" (first occurrence).

Page 18, line 2, delete "can be," insert --can,--;

line 3, after "discs," insert --be--;

line 4, delete "the description will be given to" insert --another example of--;

line 5, delete "on referring" insert --will be described with reference--;

line 7, delete "of" (second occurrence) insert --for--;

line 10, delete "the" insert --a--;

line 11, delete the second comma;

line 18, delete "there is a room";

line 19, delete "for", delete "reconstruction." insert --reconstruction can be deferred.--;

line 28, delete "difference".

Page 19, line 1, delete in its entirety insert --reconstruction time is--;

line 3, delete in its entirety insert --that the data reconstruction cannot be deferred.--;

line 12, delete "the" (second occurrence) insert --a--;

line 14, delete "the description will be given to" insert --another example of--;

line 15, delete "on referring" insert --will be described with reference--;

line 18, after "is" insert --in--;

line 25, delete "the time zone," insert --in a time zone having much processing of the normal access or read/write,--;

line 28, after "that" insert --time is in a--, delete "has" insert --having--.

Page 20, line 2, after "threshold," insert --is--;

line 3, delete "is";

line 4, delete "is", delete "for" insert --within--;

line 14, delete "embodiments" insert --examples--;

line 20, delete "the description will be given to" insert --another example of--;

line 21, delete "on referring" insert --will be described with reference--;

line 27, delete "it is not" insert --the time is not in--.

Page 21, line 5, delete "it is" insert --the time is in--;

line 13, delete "it is" insert --the time is in--;

line 16, delete "exceptionally" insert --preferentially--;

line 20, delete "the description will be given to" insert --another example of--;

line 21, delete "on referring" insert --will be described with reference--;

line 25, delete "accumulating totals of the data";

line 26, delete "reconstruction time" insert --time taken to reconstruct the faulty data--.

Page 22, line 2, delete "accumulating";

line 3, delete "totals of the data reconstruction time" insert --time taken to reconstruct the faulty data--;

line 5, delete "the" (first occurrence) insert --a--;

line 7, delete "the" insert --a--;

line 10, delete "the accumu-";

line 11, delete in its entirety;

line 12, delete "reconstruction." insert --reconstruction can be deferred.--;

line 17, delete "and";

line 18, delete "is limitlessly" insert --may have any magnitude--;

line 19, after "threshold," insert --and thus--;

line 21, after "of" (second occurrence) insert --the--;

line 27, after "reconstruction" insert --within the unit time--.

Page 23, line 3, after "reconstruction" insert --within the unit time--;

line 6, delete "will" insert --can--;

line 8, delete "the" (first occurrence) insert --a--, delete "given" insert --used--.

Page 24, line 1, delete "a room of the" insert --the remaining--;

line 7, delete in its entirety insert --time taken to reconstruct the faulty data--;

line 8, delete "sing time";

line 9, delete "the" insert --a--;

line 12, after "tion" insert --within the unit time--.

IN THE CLAIMS

Please cancel claims 1-17 without prejudice or disclaimer of the subject matter thereof.

Please add new claims 18-29 as follows:

--18. An apparatus for storing data comprising:

a plurality of storage units for storing a plurality of data groups and error correcting data corresponding to each of the data groups; and

a controller for performing processing of reconstructing data stored in any of the storage units in which a fault has occurred based on all other data of a

corresponding one of the data groups and corresponding error correcting data;

wherein the controller determines a degree of preference to be given to the processing of reconstructing data.

19. An apparatus for storing data according to claim 18, wherein the controller determines the degree of preference based on a predetermined limit time.

20. An apparatus for storing data according to claim 19, wherein the controller performs the processing of reconstructing data according to the degree of preference.

21. An apparatus for storing data comprising:

a plurality of storage units for storing a plurality of data groups and error correcting data corresponding to each of the data groups; and

a controller for performing processing of reconstructing data stored in any of the storage units in which a fault has occurred based on all other data of a corresponding one of the data groups and corresponding error correcting data, and processing of data read/write requests from a host;

wherein the controller determines whether to give preference to the processing of reconstructing data or to the processing of data read/write requests, and performs the

processing to which preference is given based on a predetermined limit time.

22. An apparatus for storing data comprising:

a plurality of storage units for storing a plurality of data groups and error correcting data corresponding to each of the data groups; and

a controller for performing processing of reconstructing data stored in any of the storage units in which a fault has occurred based on all other data of a corresponding one of the data groups and corresponding error correcting data, and processing of data read/write requests from a host;

wherein the controller controls a ratio of an amount of the processing of reconstructing data to an amount of the processing of data read/write requests, and performs a processing according to the ratio based on a predetermined limit time.

23. An apparatus for storing data according to claim 22, wherein the controller controls a ratio of an amount of the processing of reconstructing data per unit time to an amount of the processing of data read/write requests per unit time, and performs a processing according to the ratio based on a predetermined limit time.

24. An apparatus for storing data comprising:

a plurality of storage units for storing a plurality of data groups and error correcting data corresponding to each of the data groups; and

a controller for performing processing of reconstructing data stored in any of the storage units in which a fault has occurred based on all other data of a corresponding one of the data groups and corresponding error correcting data, and processing of data read/write requests from a host;

wherein the controller controls a ratio of an amount of time for the processing of reconstructing data to an amount of time for the processing of data read/write requests, and performs a processing according to the ratio based on a predetermined limit time.

25. An apparatus for storing data comprising:

a plurality of storage units for storing a plurality of data groups and error correcting data corresponding to each of the data groups; and

a controller for performing processing of reconstructing data stored in any of the storage units in which a fault has occurred based on all other data of a corresponding one of the data groups and corresponding error correcting data, and processing of data read/write requests from a host;

wherein the controller controls an amount of time for the processing of reconstructing data based on a predetermined limit time.

26. An apparatus for storing data comprising:

a plurality of storage units for storing a plurality of data groups and error correcting data corresponding to each of the data groups; and

a controller for performing processing of reconstructing data stored in any of the storage units in which a fault has occurred based on all other data of a corresponding one of the data groups and corresponding error correcting data, and processing of data read/write requests from a host;

wherein the controller controls an amount of the processing of reconstructing data based on a predetermined limit time.

27. An apparatus for storing data comprising:

a plurality of storage units for storing a plurality of data groups and error correcting data corresponding to each of the data groups; and

a controller for performing processing of reconstructing data stored in any of the storage units in which a fault has occurred based on all other data of a corresponding one of the data groups and corresponding error

correcting data, and processing of data read/write requests from a host;

wherein the controller determines an amount of performing the processing of reconstructing data instead of the processing of data read/write requests such that the processing of reconstructing data is completed within a fixed time.

28. An apparatus for storing data comprising:

a plurality of storage units for storing a plurality of data groups and error correcting data corresponding to each of the data groups; and

a controller for performing processing of reconstructing data stored in any of the storage units in which a fault has occurred based on all other data of a corresponding one of the data groups and corresponding error correcting data, and processing of data read/write requests from a host;

wherein the controller performs the processing of reconstructing data in preference to the processing of data read/write requests such that the processing of reconstructing data is completed within a fixed time.

29. An apparatus for storing data comprising:

a plurality of storage units for storing a plurality of data groups and error correcting data corresponding to each of the data groups; and

a controller for performing processing of reconstructing data stored in any of the storage units in which a fault has occurred based on all other data of a corresponding one of the data groups and corresponding error correcting data, and processing of data read/write requests from a host;

wherein the controller performs the processing of reconstructing data instead of the processing of data read/write requests such that the processing of reconstructing data is completed within a fixed time.--

IN THE ABSTRACT

Line 2, delete the colon;

Line 3, delete "striped" insert --divided--;

Line 4, delete "discs" insert --units--;

Line 5, delete "striped" insert --divided--;

Line 6, delete "the";

Line 8, delete "the" insert --a--, delete "at fault;" insert --which has failed;--;

Line 12, delete "the" (first occurrence) insert --a--;

Line 13, delete "out of" insert --from a--;

Line 14, delete "the" insert --a--, delete the comma, after "and" insert --a--;

Line 15, delete in its entirety insert --processing, and the selected processing is carried out, or the--;

Line 18, delete "processing amount" insert --amount of the data reconstruction processing within a unit time,--.

REMARKS

A new title has been provided, the abstract and the specification have been amended, claims 1-17 have been cancelled, and new claims 18-29 have been added. Claims 18-29 are pending, with claims 18, 21-22, and 24-29 being independent.

Submitted herewith is a claim for priority, acknowledgement of which is respectfully requested.

Submitted herewith is an Information Disclosure Statement, consideration of which is respectfully requested.

Submitted herewith are proposed corrections to Figs. 2 and 4-9. Upon approval of the proposed corrections and receipt of a Notice of Allowance, the drawings will be corrected in accordance with the procedure established therefor.

Please charge any shortage in fees due in connection with the filing of this paper to the deposit account of Antonelli,

Terry, Stout & Kraus, Deposit Account No. 01-2135 (500.31108CC4), and please credit any excess fees thereto.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

Carl I. Brundidge
Registration No. 29,621

CIB/RSS
(703) 312-6600

500.31108CC4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants:	A. TANAKA et al.
Serial No.:	Not Yet Assigned
Filed:	Even Date Herewith
For:	DATA RECONSTRUCTION METHOD AND SYSTEM EMPLOYING THE SAME
Group:	2785 (Anticipated)
Examiner:	H. Nguyen (Anticipated)

LETTER TO THE OFFICIAL DRAFTSMAN

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

September 29, 1998

Sir:

Subject to the Examiner's approval, the applicants hereby propose to correct Figs. 2 and 4-9 of the drawings of the above-identified application in the manner indicated in red on the attached sheets.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

Carl I. Brundidge
Registration No. 29,621

CIB/RSS
(703) 312-6600

Attachments

FIG.2

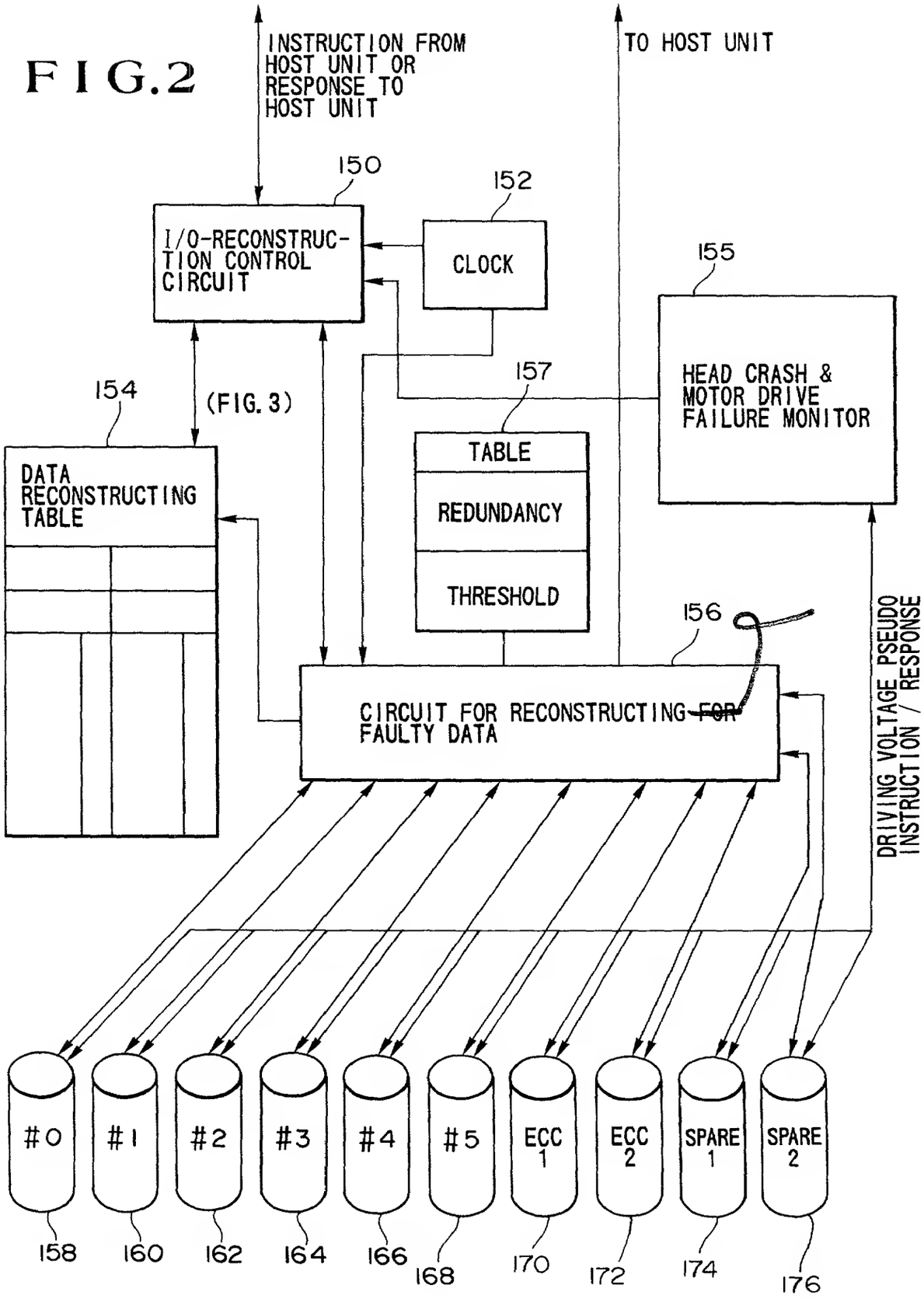

INSTRUCTION FROM HOST UNIT OR RESPONSE TO HOST UNIT
TO HOST UNIT
150
152
I/O-RECONSTRUCTION CONTROL CIRCUIT
CLOCK
155
HEAD CRASH & MOTOR DRIVE FAILURE MONITOR
157
154
(FIG.3)
TABLE
REDUNDANCY
THRESHOLD
DATA RECONSTRUCTING TABLE
156
CIRCUIT FOR RECONSTRUCTING FAULTY DATA
DRIVING VOLTAGE PSEUDO INSTRUCTION / RESPONSE
#0
#1
#2
#3
#4
#5
ECC 1
ECC 2
SPARE 1
SPARE 2
158
160
162
164
166
168
170
172
174
176

FIG.4

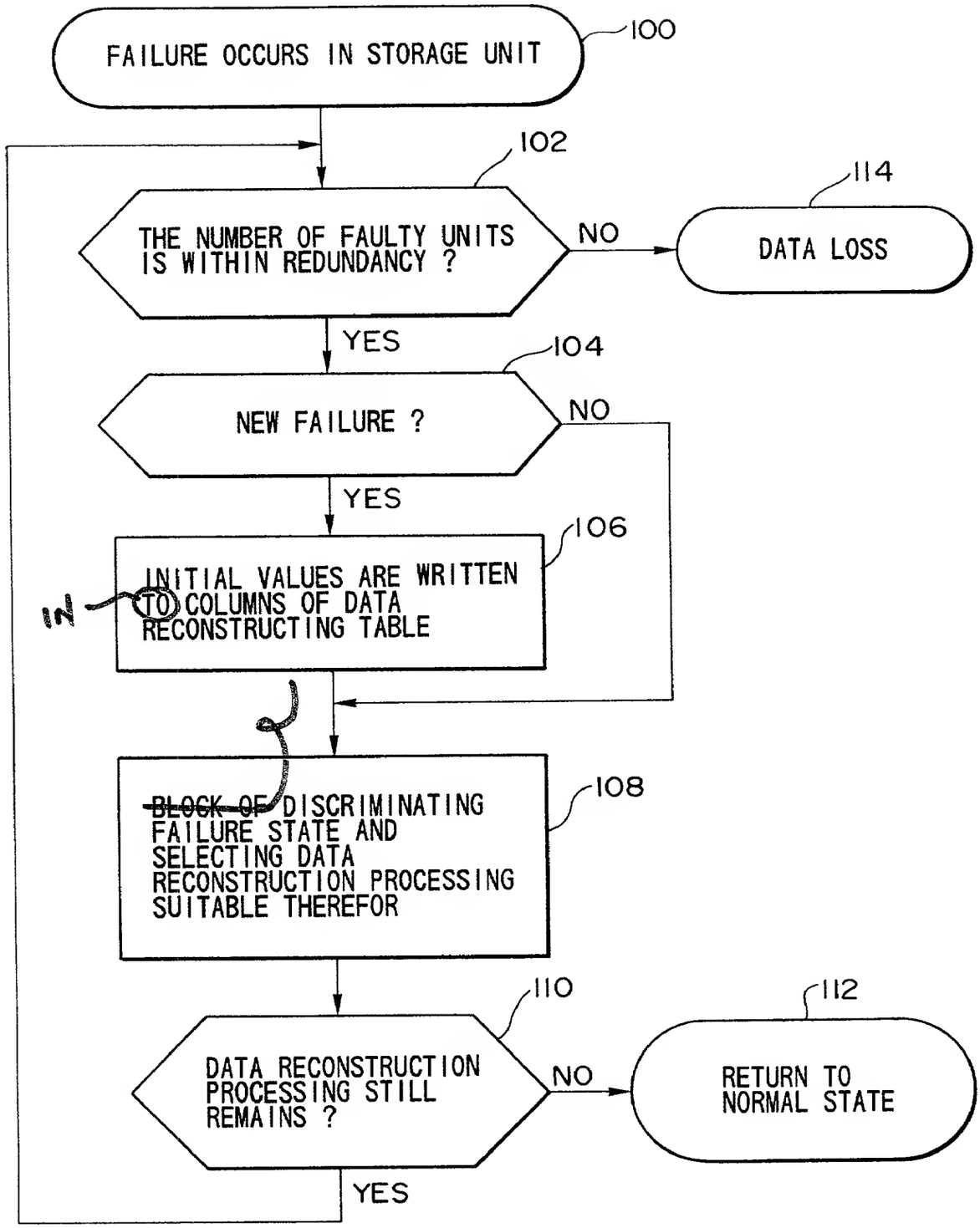

FAILURE OCCURS IN STORAGE UNIT
100
102
THE NUMBER OF FAULTY UNITS IS WITHIN REDUNDANCY ?
NO
114
DATA LOSS
YES
104
NEW FAILURE ?
NO
YES
106
INITIAL VALUES ARE WRITTEN TO COLUMNS OF DATA RECONSTRUCTING TABLE
108
BLOCK OF DISCRIMINATING FAILURE STATE AND SELECTING DATA RECONSTRUCTION PROCESSING SUITABLE THEREFOR
110
DATA RECONSTRUCTION PROCESSING STILL REMAINS ?
NO
112
RETURN TO NORMAL STATE
YES

FIG.5

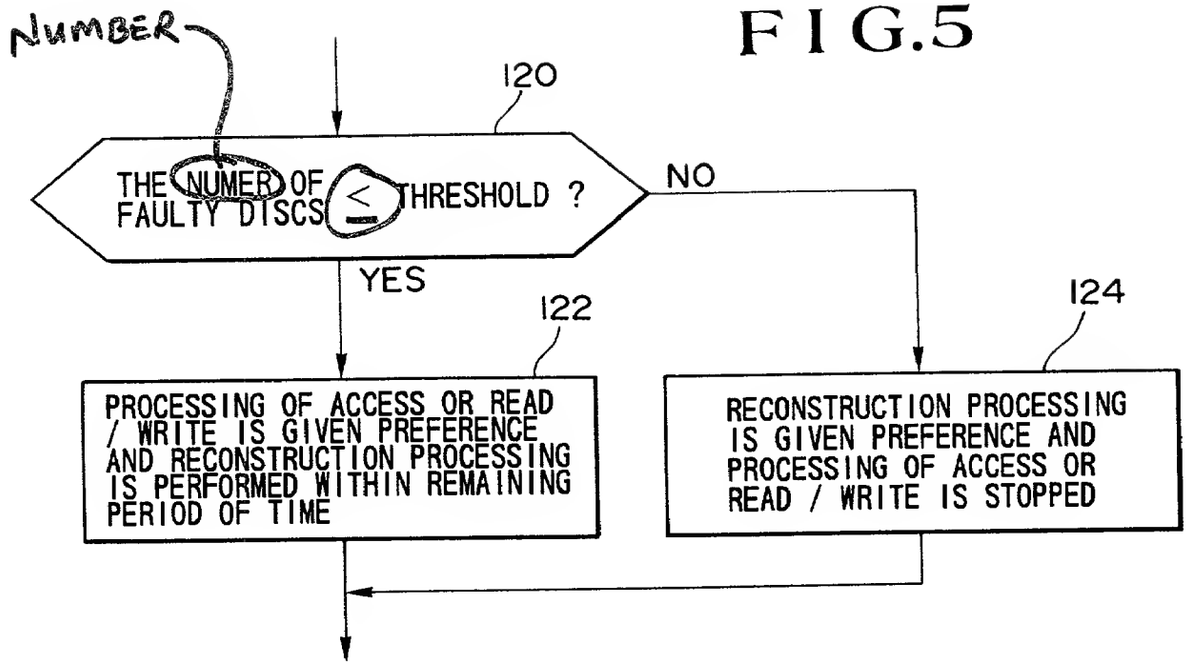

NUMBER
120
THE NUMER OF FAULTY DISCS ≤ THRESHOLD ?
NO
YES
122
PROCESSING OF ACCESS OR READ / WRITE IS GIVEN PREFERENCE AND RECONSTRUCTION PROCESSING IS PERFORMED WITHIN REMAINING PERIOD OF TIME
124
RECONSTRUCTION PROCESSING IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ / WRITE IS STOPPED

FIG.6

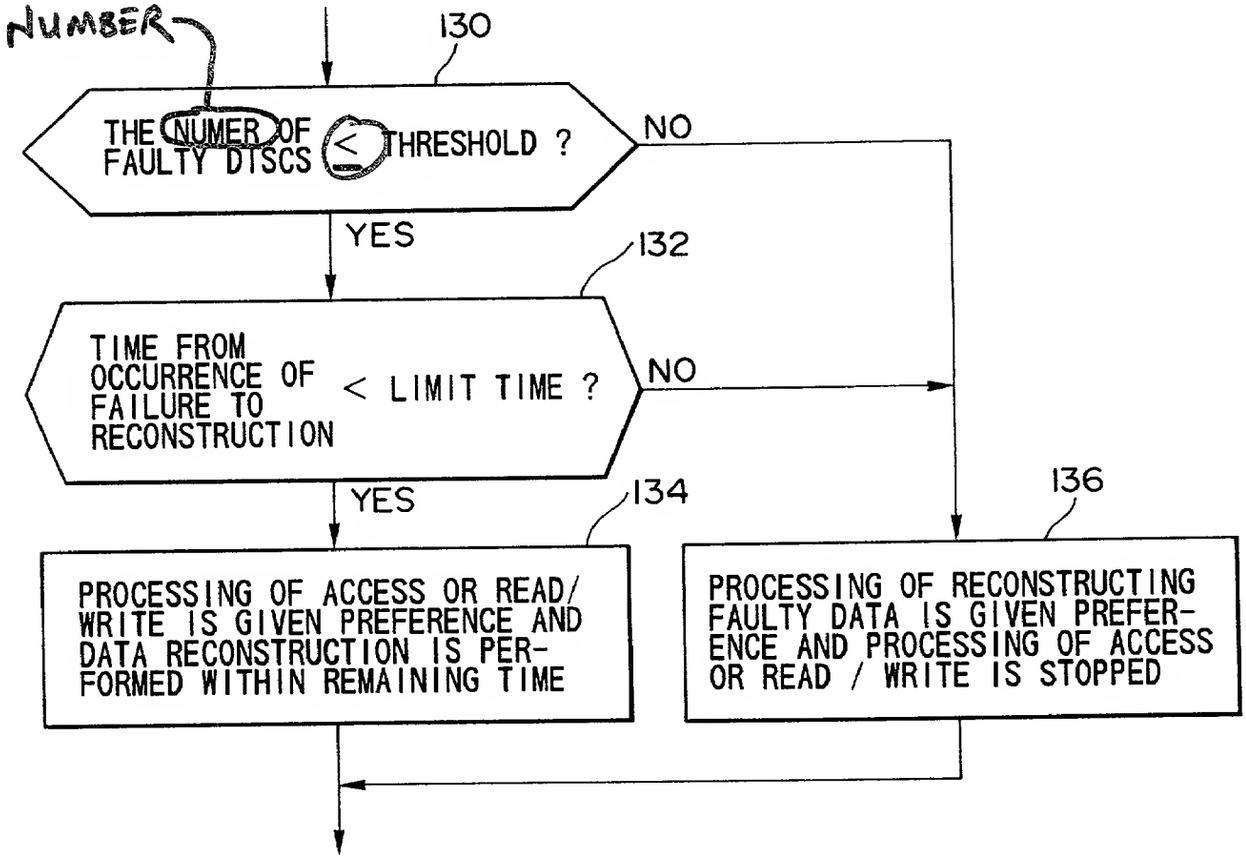

NUMBER
130
THE NUMER OF FAULTY DISCS ≤ THRESHOLD ?
NO
YES
132
TIME FROM OCCURRENCE OF FAILURE TO RECONSTRUCTION < LIMIT TIME ?
NO
YES
134
PROCESSING OF ACCESS OR READ/ WRITE IS GIVEN PREFERENCE AND DATA RECONSTRUCTION IS PERFORMED WITHIN REMAINING TIME
136
PROCESSING OF RECONSTRUCTING FAULTY DATA IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ / WRITE IS STOPPED

FIG.7

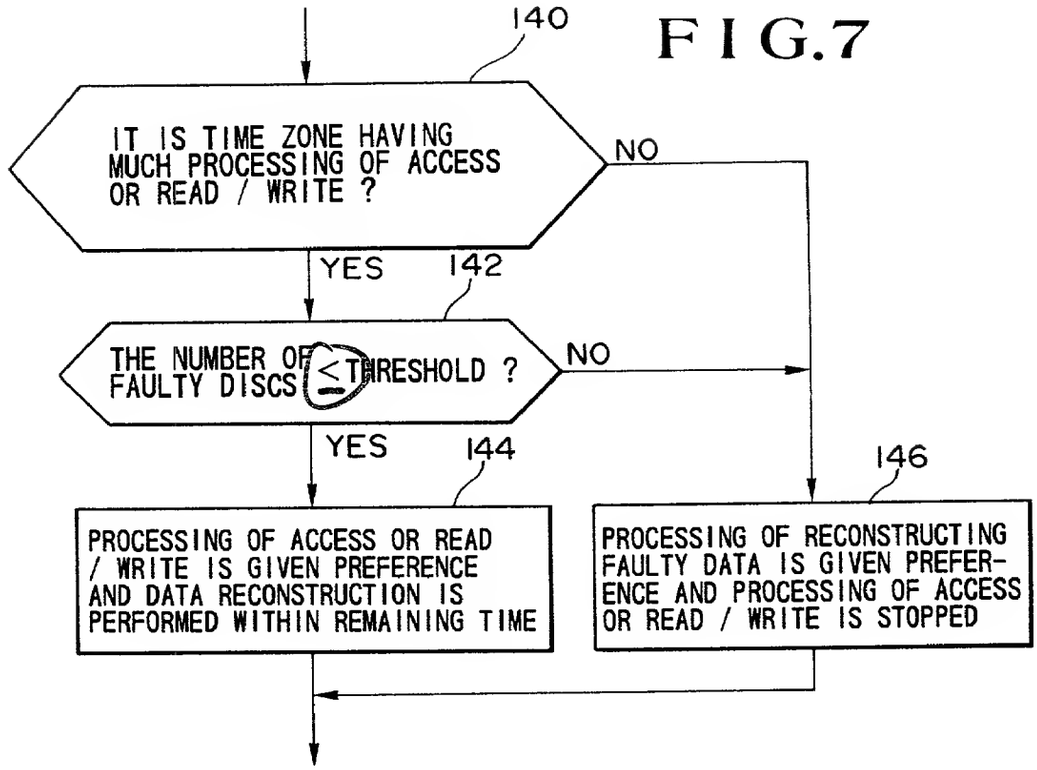
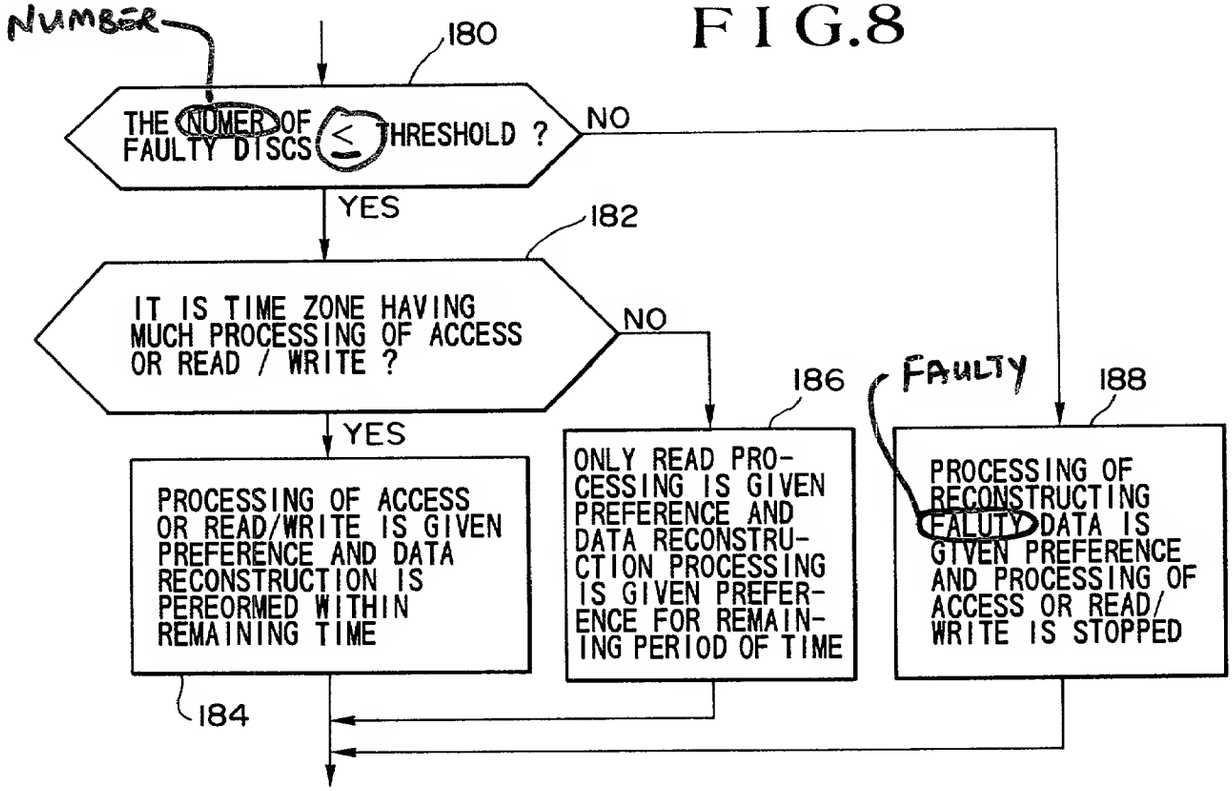

140
IT IS TIME ZONE HAVING MUCH PROCESSING OF ACCESS OR READ / WRITE ?
NO
YES
142
THE NUMBER OF FAULTY DISCS ≤ THRESHOLD ?
NO
YES
144
146
PROCESSING OF ACCESS OR READ / WRITE IS GIVEN PREFERENCE AND DATA RECONSTRUCTION IS PERFORMED WITHIN REMAINING TIME
PROCESSING OF RECONSTRUCTING FAULTY DATA IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ / WRITE IS STOPPED

FIG.8


NUMBER
180
THE NUMER OF FAULTY DISCS ≤ THRESHOLD ?
NO
YES
182
IT IS TIME ZONE HAVING MUCH PROCESSING OF ACCESS OR READ / WRITE ?
NO
YES
186
FAULTY
188
PROCESSING OF ACCESS OR READ/WRITE IS GIVEN PREFERENCE AND DATA RECONSTRUCTION IS PEREORMED WITHIN REMAINING TIME
ONLY READ PROCESSING IS GIVEN PREFERENCE AND DATA RECONSTRUCTION PROCESSING IS GIVEN PREFERENCE FOR REMAINING PERIOD OF TIME
PROCESSING OF RECONSTRUCTING FAULTY DATA IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ/ WRITE IS STOPPED
184

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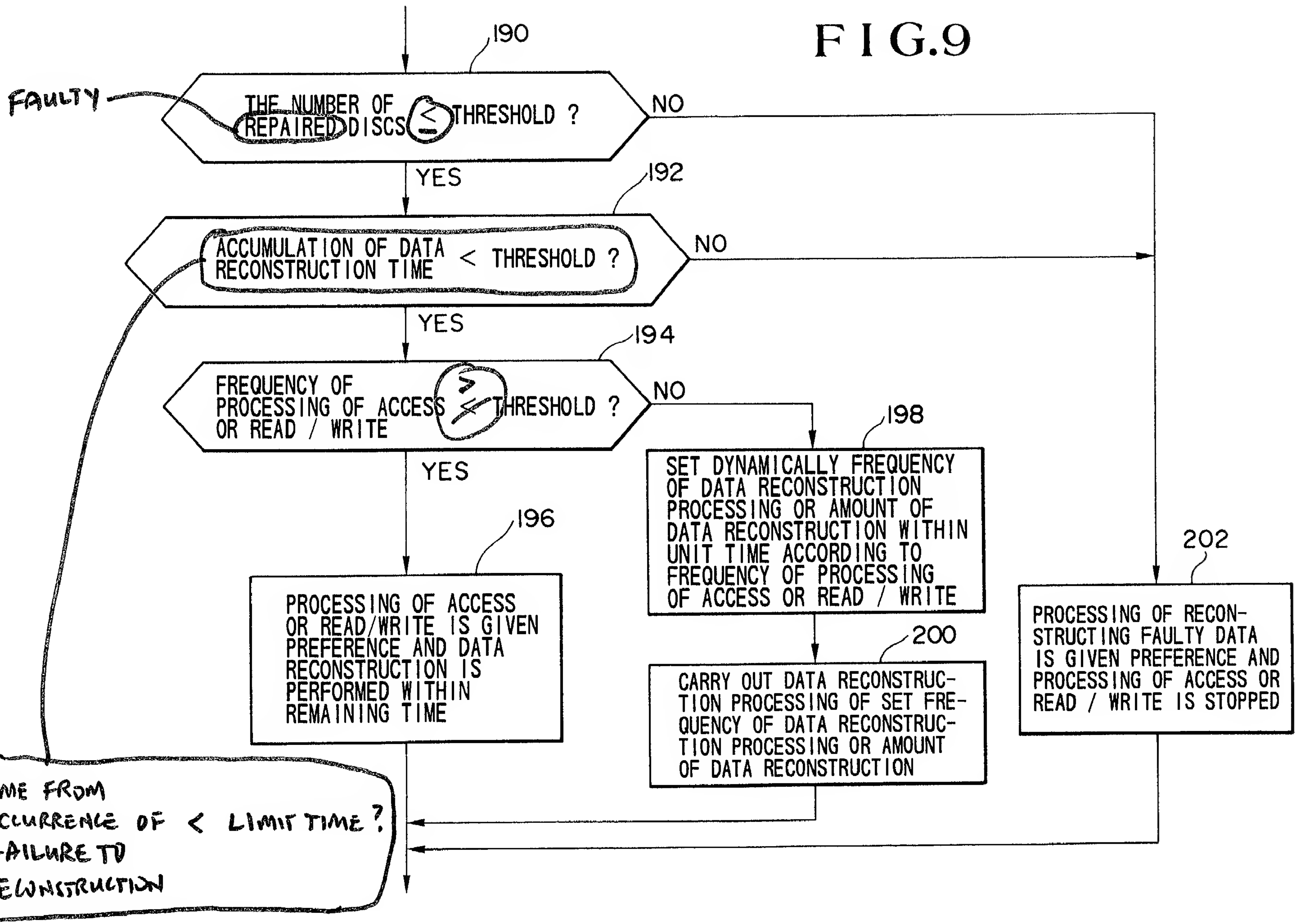

190
THE NUMBER OF REPAIRED DISCS ≤ THRESHOLD ?
FAULTY
NO
YES
192
ACCUMULATION OF DATA RECONSTRUCTION TIME < THRESHOLD ?
NO
YES
194
FREQUENCY OF PROCESSING OF ACCESS OR READ / WRITE ≥ THRESHOLD ?
NO
YES
196
PROCESSING OF ACCESS OR READ/WRITE IS GIVEN PREFERENCE AND DATA RECONSTRUCTION IS PERFORMED WITHIN REMAINING TIME
198
SET DYNAMICALLY FREQUENCY OF DATA RECONSTRUCTION PROCESSING OR AMOUNT OF DATA RECONSTRUCTION WITHIN UNIT TIME ACCORDING TO FREQUENCY OF PROCESSING OF ACCESS OR READ / WRITE
200
CARRY OUT DATA RECONSTRUCTION PROCESSING OF SET FREQUENCY OF DATA RECONSTRUCTION PROCESSING OR AMOUNT OF DATA RECONSTRUCTION
202
PROCESSING OF RECONSTRUCTING FAULTY DATA IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ / WRITE IS STOPPED
TIME FROM OCCURRENCE OF FAILURE TO RECONSTRUCTION < LIMIT TIME ?

DATA RECONSTRUCTION METHOD AND SYSTEM EMPLOYING THE SAME

BACKGROUND OF THE INVENTION

The present invention relates to a memory for performing access or read/write in parallel with a plurality of independent storage units as a set, and more particularly to a data reconstruction system and a method used therein which are available in occurrence of a failure.

The technology for controlling discs arranged in parallel is disclosed in JP-A-H1-250128 corresponds to U.S. Patent Application Serial No. 118,785 filed on November 6, 1987 and JP-A-H2-135555.

As for the technology for achieving the large capacity of a memory and the high speed transfer of data, there is known a method in which the data is striped into a plurality of data of bit unit, byte unit or arbitrary unit, with a plurality of storage units as a set, to be stored in the respective storage units, and when the data is to be read out, the plurality of data is simultaneously read out from the respective storage units. Moreover, in this method, the data to be used for a parity check is produced from the data striped up among the storage units to be stored in another storage unit. When the failure occurs in any of the storage units, the data stored in the remaining normal storage units and the data for the parity check are used to

reconstruct the faulty data, thereby to improve the reliability of the memory.

Further, there is known the technology in which when the failure occurs in any of the storage units, not only the data is reconstructed for the normal read operation, but also the data stored in the storage unit at fault is reconstructed to be stored in the normal storage unit which is additionally provided. With this technology, the reconstructed data is stored in the spare storage unit and the data is read out from the spare storage unit for the subsequent access, whereby it is possible to improve the availability of the memory.

The failure of a certain number of storage units can be repaired by providing the parity data, and the data can also be reconstructed by the provision of the spare storage unit. However, for the operation of repairing the failure, it is necessary to read out all of the data stored in the normal storage units and the data for the parity check, reconstruct the faulty data and write the reconstructed data to the spare storage unit. Therefore, during the repair of the failure, the storage units are occupied so that the request to process the normal access or read/write which is issued from a host unit continues to wait. This results in the degradation of the performance of the memory. As for the error check method for reconstructing the faulty

data, there are known the parity data, the Reed-Solomon Code and the error check code (ECC).

Although the redundancy is provided for the failure of a plurality of storage units, the failure repair in the failure of one storage unit and that in the failure of a plurality of storage units are managed without taking the distinction therebetween into consideration. Therefore, putting emphasis on the repair of the failure, since the processing of the normal access or read/write cannot be performed inspite of the failure of one storage unit, there arises a problem in that the efficiency of the processing of the normal access or read/write is reduced. On the other hand, putting emphasis on the normal access or read/write operation, there arises a problem in that the time required for the repair of the failure is not secure during the failure of a plurality of storage units, and as a result, the possibility that the whole system may break down will be increased.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to minimize the reduction of the processing of the normal access or read/write in the failure, limit the time required for the repair of the failure within a fixed period of time, and ensure the high reliability, with respect to a memory which has the redundancy for the failure of two or more storage units.

It is another object of the present invention to provide a data reconstruction system which is capable of selecting a suitable data reconstruction method in correspondence to the various kinds of conditions relating to the repair of the failure and carrying out the most suitable data reconstruction processing.

It is still another object of the present invention to provide a control system which is capable of changing the procedure of data reconstruction processing in correspondence to the change of redundancy relating to the number of ECC discs included in a plurality of storage units which are arranged in parallel to one another.

The above objects of the present invention are attained by the provision of a memory comprising: a group of storage units for striping data into a plurality of data of bit unit, bite unit or arbitrary unit to store therein the striped data, the plurality of independent storage units forming a set; discs for storing therein ECC data corresponding to the striped data; a spare storage unit for storing therein the reconstructed data; an I/O-reconstruction control circuit for receiving a command relating to I/O issued from a host unit to execute processing in accordance with the command or respond to the host unit; a timer for giving the point of failure, an elapsed time during the data reconstruction, a unit time and the like; a data reconstructing table for the storage unit at fault;

and a faulty data reconstructing circuit for performing discovery of the faulty data, data reconstruction and an operation of writing data to a spare storage disc, wherein when a failure occurs in any of the storage units, the faulty data reconstructing circuit detects the failure by an error check to inform the I/O-reconstruction control circuit of the failure, and the I/O-reconstruction control circuit discriminates a state of the failure to select the preferred processing suitable for the state of the failure out of the processing of the normal access or read/write and the data reconstruction processing, thereby to execute the selected processing, or set the frequency of the processing of the normal access or read/write and the data reconstruction, or the ratio of the processing amount.

When the failure occurs in the above memory, the redundancy of the memory, the elapsed time during the data reconstruction, and the state of the normal access or read/write processing and the like are discriminated, and the data reconstruction processing (method) suitable therefor is selected. Therefore, it is possible to prevent reduction of the performance of the processing of the normal access or read/write and ensure the high reliability of the memory. More specifically, in the case where the number of storage units at fault has a room for the redundancy of the memory, there is selected the data reconstruction

processing (method) in which the processing of the normal access or read/write is given preference, and the faulty data is reconstructed within the remaining period of time. Therefore, no load is put on the processing of the normal access or read/write. On the other hand, in the case where there is no room in the redundancy, since the processing of reconstructing faulty data is given preference, it is possible to ensure the reliability for the failure of the memory. Moreover, in the case where there is a room in the redundancy, since the data reconstruction processing (method) is changed according to the magnitude of the accumulating totals of time which was taken to repair the failure with respect to the storage units in which the failure occurred, it is possible to prevent reduction of the performance of the processing of the normal access or read/write and limit the time required for the data reconstruction within a fixed period of time. Moreover, the time zone, e.g., the night having less processing of the normal access or read/write is selected so that the system can devote itself to the data reconstruction. As a result, it is possible to reduce the load of the memory in the time zone having much processing of the normal access or read/write. Moreover, since the frequency of the data reconstruction processing, or the ratio of the amount of data reconstruction is set according to the magnitude of the frequency of the processing of the normal access or

read/write, it is possible to carry out the data reconstruction processing effectively in a time aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flow chart of the processing of reconstructing faulty data according to the present invention;

Fig. 2 is a block diagram showing the arrangement of a memory according to the present invention;

Fig. 3 is a diagram showing the arrangement of a data reconstructing table for a disc at fault of the present invention;

Fig. 4 is a flow chart showing the processing employed in the memory of Fig. 2;

Fig. 5 is a flow chart of a block of selecting the data reconstruction processing in Fig. 4;

Fig. 6 is another flow chart of a block of selecting the data reconstruction processing in Fig. 4;

Fig. 7 is still another flow chart of a block of selecting the data reconstruction processing in Fig. 4;

Fig. 8 is yet another flow chart of a block of selecting the data reconstruction processing in Fig. 4; and

Fig. 9 is a further flow chart of a block of selecting the data reconstruction processing in Fig. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The description will hereinafter be given to a flow chart showing the processing of reconstructing faulty data of Fig. 1.

It is assumed that a failure occurs in a memory or a motor (Step 10). In this connection, this failure is detected by the check of an error check code or by the check of the deviation of a motor driving voltage from a predetermined range. First, it is judged whether or not the failure thus occurred is repairable (Step 20). If not, then, the data reconstruction processing is completed. This results in the data loss (Step 30). If so, it is judged on the basis of the redundancy of the memory, the elapsed time of the data reconstruction and the processing state of the processing of the normal access or read/write whether or not it is a state in which the system should devote itself to the data reconstruction (Step 40). If a request to process the normal processing such as access or read/write is issued from a host unit under the condition in which there is a sufficient room and the urgency of the reconstruction is low, the data reconstruction processing is stopped and the normal processing such as access or read/write is given preference. Then, the data reconstruction processing is performed within the remaining period of time, and the processing of access or read/write during the data reconstruction is cancelled or queued (Step 50).

Conversely, if there is no room and the urgency of the reconstruction is high, the data reconstruction processing is given preference, and all of the normal processing such as access or read/write is cancelled or queued (Step 60). Moreover, in the case of the intermediate state in which there are some combinations between the urgency of the data reconstruction and the significance of the normal processing such as access or read/write, the data reconstruction processing corresponding to the individual conditions is previously prepared in the form of programs. Then, when the conditions are changed, it can proceed to the suitable processing by replacing an old program with a new one (Step 70). Next, when the data reconstruction processing is completed or interrupted, it is checked whether or not the data reconstruction processing still remains (Step 80). After all of the data reconstruction processing has been completed, the memory returns to the normal state. If the data reconstruction processing still remains, the flow returns to Step 20 and the above Steps will be repeated until the data reconstruction is completed.

Next, the description will be given to a block diagram showing the arrangement of an embodiment of the present invention of Fig. 2.

In Fig. 2, the reference numeral 150 designates an I/O-reconstruction control circuit which receives a command relating to I/O issued from the host

unit to carry out the processing according to the command or respond to the host unit. Further, when the failure is occurring in any of the storage units, the circuit 150 serves to select a suitable data reconstruction method on the basis of the number of discs during the reconstruction, the time taken to reconstruct the faulty data, the frequency of the data reconstruction, or the amount of the data reconstruction, and the like. There is connected to the individual storage units a monitor 155 which monitors that after the power source for driving the storage units is activated, the driving voltage is in a predetermined range and feeds a pseudo-instruction for reading out the data previously stored in a predetermined location to the storage units getting into the running state to monitor the responses sent therefrom. The reference numeral 154 designates a data reconstructing table for the storage unit at fault of which details will be described on referring to Fig. 3. The reference numeral 152 designates a clock or timer for obtaining the point of failure by giving the time of day and obtaining the elapsed time during the reconstruction and the unit time by a certain method. Then, the data reconstruction method can be changed with the time measured by the timer as one condition. The reference numeral 156 designates a circuit for reconstructing faulty data which performs the discovery of the faulty data, the data reconstruction and the write of the data to a spare storage disc. Moreover, the

circuit 156 reads out the data from all of the discs except the disc at fault, reconstructs the faulty data using the data thus read out, and transfers the reconstructed data to the host unit and writes it to the spare storage disc. The reference numerals 158 to 168 designate a group of data discs for storing therein the striped data. Although the six discs are shown as the data discs in Fig. 2, the number thereof is generally arbitrary. The reference numerals 170 and 172 designate discs which store therein the ECC data corresponding to the striped six data which is stored in the discs 158 to 168. When the failure occurs, the faulty data is reconstructed using the ECC data and the normal data among the data 158 to 168. In this connection, the redundancy which the memory has corresponds to the number of ECC discs with respect to the number of discs up to a certain number. But, in the case where the discs break down of which number is more than that certain number, it is impossible to reconstruct the faulty data. This results in the data loss. Fig. 2 shows that even when the number of ECC data is two, i.e., the two data discs break down, the faulty data can be reconstructed. However, since there is generally known the ECC production method which stands up to the failure of two or more discs, the number of faulty discs which does not result in the data loss, i.e., the redundancy can be increased. The ECC production is concretely realized using the Reed-Solomon Code. The

Reed-Solomon Code and the error correction method employing the same themselves are well known. The reference numerals 174 and 176 designate spare storage units for storing therein the reconstructed data. Then, in the case where the storage contents of the faulty disc are stored in the spare storage unit, that spare storage unit is accessed with the data stored therein after the next time. The number of those discs is generally arbitrary.

The description will now be given to the data reconstructing table for the disc at fault.

The data reconstructing table 154 includes the identification number of the spare storage disc (1), the identification number of the disc at fault (2), the point of failure (3), the sector or address of the faulty data (4), and the flag used to judge whether or not the failure is repairable (5).

Next, the operations of the memory of Fig. 2 and the table of Fig. 3 will be described on the basis of a flow chart shown in Fig. 4.

First, in Fig. 2, it is assumed that the failure occurs in the data disc unit 162 (Step 100). Then, the circuit 156 for reconstructing faulty data detects that failure to inform the I/O-reconstruction control circuit 150 of that failure. After receiving that information from the circuit 156, the circuit 150 checks whether or not an unoccupied space is present in the data reconstructing table 154 by referring to the

table 154 (Step 102). Subsequently, the circuit 150 checks whether or not that failure is a failure which occurred in a new disc (Step 104). If so, the circuit 150 instructs the circuit 156 to write the following initial values to the columns of interest in the data reconstructing table 154 of Fig. 3. That is, the circuit 156 writes the identification number SPARE 1 of the spare disc 174 to the column of the spare storage unit in the data reconstructing table 154, and writes the identification number #2 of the data disc 162 at fault to the column of the storage unit at fault. Next, the circuit 156 writes the point of failure read out from the timer 152 to the column of the point of failure, and writes the failure occurrence address in the faulty disc 162 to the column of address. Finally, the circuit 156 initializes the reconstruction judgement flag of each address (Step 106). If that failure is not a new one, the processing of Step 106 is not executed, but the processing proceeds to the subsequent Step. In the subsequent Step, the circuit 150 discriminates the state of the failure, selects either the processing of the normal access or read/write, or the data reconstruction processing which is suitable for the state of the failure, and executes the selected processing (Step 108). The details of this Step 108 will be described on referring to Fig. 5 to Fig. 9. Next, when the data reconstruction processing is completed or interrupted, it is checked whether or not

the data reconstruction processing still remains (Step 110). When all of the data reconstruction processing is completed, the memory returns to the normal state. When the data reconstruction processing still remains, the processing returns to Step 102, then, the above Steps will be repeated until all of the data reconstruction processing is completed. Even if any data reconstruction method is chosen, the circuit 156 monitors the continuation or completion of the data reconstruction processing. In the case where the subsequent failure occurs when the data reconstruction of interest has not yet been completed, the circuit 156 starts performing the processing in the same manner as described above (Step 102). Then, in the case where the number of faulty discs of which data reconstruction in not completed exceeds the redundancy of the memory, since the data reconstruction is impossible, the circuit 150 informs the host unit of the data loss (Step 114). If the data reconstruction processing is completed, the unnecessary data in the data reconstructing table 154 is erased and the memory returns to the normal state (Step 112). The address in the table 154 may have a track unit, a sector unit, a word unit or any unit.

Next, the description will be given to Step 108 of Fig. 4 on referring to Fig. 5.

In Fig. 5, the I/O-reconstruction control circuit 150 counts the number of discs of which data reconstruction is not completed by referring to the data

reconstructing table 154, and compares the number of faulty discs with the threshold (Step 120). If the number of faulty discs is less than the threshold which is previously set to a value less than or equal to the redundancy, the circuit 150 judges that there is a room in the redundancy, gives the processing of access or read/write preference and performs the processing of reconstructing faulty data within the remaining period of time. All of the processing such as access or read/write during the reconstruction waits, i.e., it is cancelled or queued (Step 122). On the other hand, if the number of faulty discs is more than the threshold, the circuit 150 judges that the redundancy has no room, gives the data reconstruction processing preference, and cancels or queues all of the normal processing such as access or read/write (Step 124).

The reconstruction is performed with a unit, such as 1 track, in which the repair and the storage are completed for a relatively short period of time. After the completion of the reconstruction, the memory is opened for the normal processing. But, when the instruction of the processing of access or read/write is issued from the host unit during the reconstruction, the data reconstruction work is stopped immediately, and then the memory is opened for the processing of access or read/write. In the case where during the processing of access or read/write, the data which has not yet been reconstructed is read out, the faulty data is then

reconstructed using the ECC data and the normal data which was used when producing the ECC data, and the reconstructed data is sent to the host unit. At the same time, the reconstructed data is stored in the spare disc and the reconstruction judgement flag of the address column of interest in the data reconstructing table 154 is set to the completion of the reconstruction. If this flag is set to the completion of the reconstruction, the subsequent access to this data is performed with the spare disc. In the case of write of data, after the ECC data has been produced, the data to be stored in the faulty disc is stored in the spare disc, and then the reconstruction judgement flag is set to the completion of the reconstruction.

Since in the example of Fig. 2, the redundancy is two, it is proper that the threshold is necessarily set to 1. However, in the case where the Reed-Solomon Code capable of correcting the multiplex dissipation with two or more discs is used, the threshold may have an arbitrary integral number less than or equal to the redundancy. Those values are previously set in the table 157.

Since the I/O-reconstruction control circuit 150 stores the address of the data which was reconstructed at the last time, the data reconstruction is performed from the subsequent address. In the reconstruction, the address of the data which was reconstructed at the last time and previously stored is used. Then,

when the flag is not set in the data reconstructing table 154 and thus the data reconstruction is not completed with respect to the subsequent address, the data of that address is reconstructed. The reconstruction of the data is performed in such a way that the ECC data and the normal data which was used to produce the ECC data from the normal discs are read out and the circuit 156 for reconstructing faulty data is used. The reconstructed data is written to the spare disc and the flag in the data reconstructing table 154 is set to the completion of the data reconstruction. Then, the reconstructed data in the spare disc will be accessed. The address of the reconstructed data is stored in the circuit 156, and the processing by the circuit 150 proceeds to the subsequent data reconstruction processing.

In the embodiment of Fig. 5, when the number of faulty discs is less than or equal to the threshold, the processing of the normal access or read/write takes precedence over the data reconstruction. Therefore, it is possible to reduce degradation of the performance of access or read/write of the memory. Moreover, since in a state in which the system devotes itself to the data reconstruction, the reconstruction can be performed for the short period of time, it is possible to maintain the reliability of the memory.

In the above embodiments, the data reconstruction method is selected by paying attention to only the

number of faulty discs. However, the elapsed time taken to reconstruct the faulty data can be, in addition to the number of faulty discs, included in the conditions.

Next, the description will be given to Step 108 of Fig. 4 on referring to Fig. 6.

In Fig. 6, the I/O-reconstruction control circuit 150 counts the number of discs of which reconstruction is not yet completed by referring to the data reconstructing table 154, and compares the number of faulty discs with the threshold (Step 130). If that number is less than or equal to the threshold, then, the circuit 150 reads the present time from the timer 152, and compares the time taken to reconstruct the faulty data, which can be calculated from the present time and the point of failure in the data reconstructing table 154, with a predetermined limit time (Step 132). Then, if the reconstruction time is less than the predetermined limit time, it is considered that there is a room for the data reconstruction. Therefore, the circuit 150 instructs the circuit 156 for reconstructing faulty data to give the processing of the normal access or read/write preference, reconstruct the data in the faulty discs within the remaining period of time, and store the reconstructed data in the spare disc. The request to perform the processing of access or read/write issued from the host unit during the reconstruction is cancelled or queued (Step 134). If the number of faulty discs is more than the threshold, or the difference

between the present time and the point of failure is more than the predetermined limit time, it is considered that there is no room for the data reconstruction. Therefore, the circuit 150 cancels or queues the command of the normal access or read/write issued from the host unit and instructs the circuit 156 to give the data reconstruction preference (Step 136).

In the embodiment of Fig. 6, when the time taken to reconstruct the faulty data exceeds the limit time, the system devotes itself to the processing of reconstructing faulty data. Therefore, it is possible to limit the reconstruction time within the fixed period of time and improve the reliability of the memory.

Next, the description will be given to Step 108 of Fig. 4 on referring to Fig. 7.

In Fig. 7, the I/O-reconstruction control circuit 150 obtains the present time from the timer 152 and judges whether or not that time is a time zone having much processing of the normal access or read/write (Step 140). If not, the circuit 150 cancels or queues the command of the normal access or read/write issued from the host unit, and instructs the circuit 156 for reconstructing faulty data to give the data reconstruction preference. Moreover, even if that time is the time zone, when the number of faulty discs of Step 142 exceeds the threshold, similarly, the data reconstruction processing is given preference (Step 146). Only when that time zone has much processing of the

normal access or read/write and the number of faulty discs is less than or equal to the threshold, the processing of the normal access or read/write is given preference and the data reconstruction is performed for the remaining period of time (Step 144).

In the embodiment of Fig. 7, when it is previously known that the method of using the memory depends on the time zone, the data reconstruction processing can be assigned to the time zone having less processing of access or read/write. Therefore, the data reconstruction processing can be smoothly carried out without the processing of access or read/write hindering the data reconstruction processing.

In the above-mentioned embodiments of Fig. 5 to Fig. 7, there are provided two kinds of data reconstruction processing in which the reconstruction or the processing of access or read/write is given preference. However, the kind of data reconstruction processing may be increased in correspondence to the circumstances.

Next, the description will be given to Step 108 of Fig. 4 on referring to Fig. 8.

In Fig. 8, when the number of faulty discs exceeds the threshold in Step 180, the data reconstruction processing is given preference and the processing of the normal access or read/write is stopped (Step 188). When the number of faulty discs is less than or equal to the threshold, and it is not the time zone having much processing of the normal access or

read/write in Step 182, only the read processing is performed and the data reconstruction processing is given preference for the remaining period of time (Step 186). When the number of faulty discs is less than or equal to the threshold and it is the time zone having much processing of the normal access or read/write, the processing of the normal access or read/write is given preference and the data reconstruction processing is performed within the remaining period of time (Step 184).

In the embodiment of Fig. 8, when the number of faulty discs is less than or equal to the threshold, but it is the time zone having less processing of the normal access or read/write, especially, the time zone having only the read processing, the read processing is exceptionally allowed to be performed, whereby it is possible to reduce degradation of the performance of the memory without hindering the data reconstruction processing.

Next, the description will be given to Step 108 of Fig. 4 on referring to Fig. 9.

In Fig. 9, when the number of faulty discs exceeds the threshold in Step 190, or the number of faulty discs is less than or equal to the threshold in Step 190 and the accumulating totals of the data reconstruction time exceeds the limit time in Step 192, the data reconstruction processing is given preference and the processing of the normal access or read/write is

stopped (Step 202). When the number of faulty discs is less than or equal to the threshold and the accumulating totals of the data reconstruction time is less than the limit time, the I/O-reconstruction control circuit 150 reads the unit time from the timer 152, and compares the frequency of the processing of the normal access or read/write within that unit time with the predetermined threshold (Step 194). When the frequency of the processing of the normal access or read/write is more than the threshold, it is considered that the accumulation is within the limit time and there is a room for the data reconstruction. Therefore, the processing of the normal access or read/write is given preference and the data reconstruction processing is performed within the remaining period of time (Step 196). On the other hand, when the frequency of the processing of the normal access or read/write is less than the threshold, and the frequency thereof is limitlessly near or far from the threshold, the frequency changes in magnitude. Therefore, the frequency of the data reconstruction processing or the ratio of the amount of data reconstruction within the unit time is dynamically set according to the magnitude of the frequency of the processing of the normal access or read/write (Step 198). Then, the data reconstruction processing is carried out according to the frequency of the data reconstruction processing or the ratio of the amount of the data reconstruction thus set (Step 200).

In the embodiment of Fig. 9, the frequency of the data reconstruction processing or the ratio of the amount of the data reconstruction is set according to the magnitude of the frequency of the processing of the normal access or read/write. Therefore, the data reconstruction processing will be carried out effectively in a time aspect.

Although the magnetic disc is given as the storage unit in the above-mentioned embodiments, the present invention is not limited thereto or thereby. That is, alternatively, an optical disc, a floppy disc, or a semiconductor memory may be used as the storage unit.

Moreover, as the conditions for selecting the data reconstruction method, instead of the above embodiments, the job contents of the host unit, the significance of the file in the memory, and the like may be used as the conditions. The combination of those conditions and the data reconstruction method allows the flexible data reconstruction processing to be performed.

According to the above embodiments, when the number of storage units at fault is less than the redundancy of the memory, the processing of access or read/write takes precedence over the data reconstruction processing. Therefore, the load of the memory is not increased so that it is possible to reduce degradation of the response performance of the memory in the processing of access or read/write to the utmost.

Moreover, since when a room of the redundancy becomes small, the processing of access or read/write is automatically stopped and the data reconstruction processing is given preference, the reliability of the memory is not reduced. Further, since the data reconstruction processing method is changed according to the accumulating totals of the data reconstruction processing time of the storage units at fault, it is possible to realize the memory of higher reliability. Moreover, since the frequency of the data reconstruction processing or the ratio of the amount of the data reconstruction is set according to the magnitude of the frequency of the processing of access or read/write, it is possible to carry out the data reconstruction processing effectively in a time aspect.

CLAIMS

1. A storage system comprising:

a plurality of data storage means including therein striped data arranged in parallel;

at least one error code storage means for storing therein error check data for the data stored in said plurality of data storage means;

at least one spare storage means for storing therein reconstructed data;

monitor means for monitoring a failure in said plurality of data storage means;

comparison means for comparing, when it is detected that a failure occurs in any of said plurality of data storage means, before the data is reconstructed on the basis of the data stored in the remaining data storage means and the data stored in said error code storage means, a value predetermined according to the number of said error code storage means, and the number of the data storage means at fault with each other; and

reconstruct means responsive to output of said comparison means for reconstructing the data based on the basis of the data stored in the remaining data storage means.

2. A storage system according to Claim 1, further comprising:

means for discriminating, when said monitor means detects a failure, the data storage means at fault

and judging whether or not the failure had already occurred in the data storage means at fault; and

decision means for determining that when a difference in said comparison means is large, access to said plurality of data storage means is given preference, and when the difference therein is small, the data is immediately reconstructed on the basis of the data in the remaining data storage means and the data in said error code storage means.

3. A storage system according to Claim 1, further comprising:

time of day means; and

a table for storing therein a number of the data storage means of which failure is discriminated, the point of failure, and a flag representing an address of the faulty data, together with a number of the spare storage means assigned for the data reconstruction.

4. A storage system according to Claim 1, further comprising:

time of day means;

means for judging whether or not the time when the failure occurred in any of said data storage means is within a predetermined access busy time zone; and

means for determining that when the result given by said judgement means is not within the predetermined access busy time zone, only the read access to said plurality of data storage means is given preference.

5. A storage system according to Claim 1, further comprising:

time of day means; and

means connected to said time of day means and said monitor means for monitoring whether or not when starting said plurality of data storage means, said error code storage means and said spare storage means, a starting voltage for said means is within a predetermined range.

6. A storage system according to Claim 1, further comprising:

time of day means; and

check means connected to said time of day means and said monitor means for sending a pseude-instruction for reading out the data stored in a predetermined location to said plurality of data storage means, said error code storage means and said spare storage means, thereby to check responses sent therefrom.

7. A storage system according to Claim 1, further comprising:

time of day means; and

check means connected to said time of day means and said monitor means for checking an error on the basis of the data which is read out from said error code storage means, when the data in said plurality of data storage means is accessed.

8. A storage system according to Claim 1, further comprising:

time of day means; and

means for judging whether or not a period of time from the time when a failure occurs in any of said data storage means to the present time is within a predetermined limit time zone and making, when the period of time exceeds the limit time zone, the data reconstruction take precedence over the access to said data storage means.

9. A data reconstruction system for a memory comprising:

a group of storage units for striping data into plural data of bit unit, byte unit or arbitrary unit, the plural independent storage units forming a set;

discs for storing therein ECC data corresponding to the striped data;

a spare storage unit for storing therein reconstructed data;

an I/O-reconstruction control unit for receiving a command relating to I/O issued from a host unit to execute processing according to the command or respond to said host unit;

a data reconstructing table for the storage unit at fault;

a circuit for reconstructing faulty data which performs discovery of faulty storage unit, data

reconstruction, and write of the reconstructed data to said spare storage unit,

said faulty data reconstructing circuit detecting, when a failure occurs in any of said storage units, the failure by an error check to inform said I/O-reconstruction control circuit of the failure occurrence, said I/O reconstruction control circuit discriminating a state of the failure; and

judgement means for selecting preferred processing suitable for the state of the failure out of processing of access or read/write and data reconstruction processing, thereby to carry out the selected processing.

10. A data reconstruction system for a memory according to Claim 9, wherein said I/O-reconstruction control circuit sets the frequency of the processing of access or read/write and data reconstruction, or the ratio of the processing amount, in correspondence to the state of the failure.

11. A data reconstruction system for a memory according to Claim 9, further comprising:

a timer for giving the point of failure, and the present time; and

means for comparing the elapsed time during the restriction with a predetermined limit time to select the preferred processing operation.

12. A data reconstruction method used with a memory comprising the steps of:

performing access or read/write to or from data in parallel which is stored in storage units by striping data into the plural data of bit unit, byte unit or arbitrary unit, with the plural independent storage units as a set, and performing an error check during the access or read/write to or from the data;

detecting, when a failure occurs, the storage unit at fault by the error check, and reconstructing data stored in the storage unit at fault as long as the number of storage units at fault is within a predetermined value, while performing the processing of the normal access or read/write;

storing the reconstructed data in a spare storage unit; and

determining that either the processing of the normal access or read/write, or the data reconstruction processing is given preference in correspondence to a state of the failure.

13. A data reconstruction method used with a memory according to Claim 12, further comprising the steps of:

judging whether or not the number of storage units of which failure is not yet completed exceeds the threshold; and

changing the priority of the processing of the normal access or read/write, or the data reconstruction processing.

14. A data reconstruction method used with a memory according to Claim 12, wherein the priority of the processing of the normal access or read/write, or the data reconstruction processing is changed in accordance with the number of storage units of which failure is not yet reconstructed, and the reconstruction processing time of the storage units which broke down.

15. A data reconstruction method used with a memory according to Claim 12, wherein the priority of the processing of the normal access or read/write, or the data reconstruction processing is changed in accordance with the number of storage units of which failure is not yet reconstructed, and the time zone when the processing of the normal access or read/write is performed.

16. A data reconstruction method used with a memory according to Claim 12, wherein the priority of the processing of access or read/write, or the data reconstruction processing is changed in accordance with the number of storage units of which failure is not yet reconstructed, the accumulating totals of the reconstruction processing time of the storage units which broke down, and the frequency of the processing of access or read/write within a unit time.

17. A data reconstruction method used with a memory according to Claim 16, wherein when the frequency of the processing of access or read/write within a unit time is less than the threshold, the frequency of the

data reconstruction processing within the unit time or the ratio of the amount of data reconstruction processing is dynamically set in accordance to the frequency of the processing of access or read/write within the unit time.

ABSTRACT OF THE DISCLOSURE

A storage data reconstruction system including: a plurality of storage units for storing therein striped data, the plural independent storage units forming a set; discs for storing therein ECC data corresponding to the striped data; a spare storage unit for storing therein the reconstructed data; an I/O-reconstruction control circuit; a timer; a data re-constructing table for the storage unit at fault; and a circuit for reconstructing faulty data. When a failure occurs in any of the storage units, the failure is detected by an error check, a state of the failure is discriminated, the preferred processing suitable for the state of the failure is selected out of processing of the normal access or read/write, and data reconstruction processing to carry out the selected processing, or the frequency of the processing of the normal access or read/write and the data reconstruction processing, or the ratio of the processing amount is set. The time taken to reconstruct the faulty data does not exceed a fixed period of time.

FIG.1

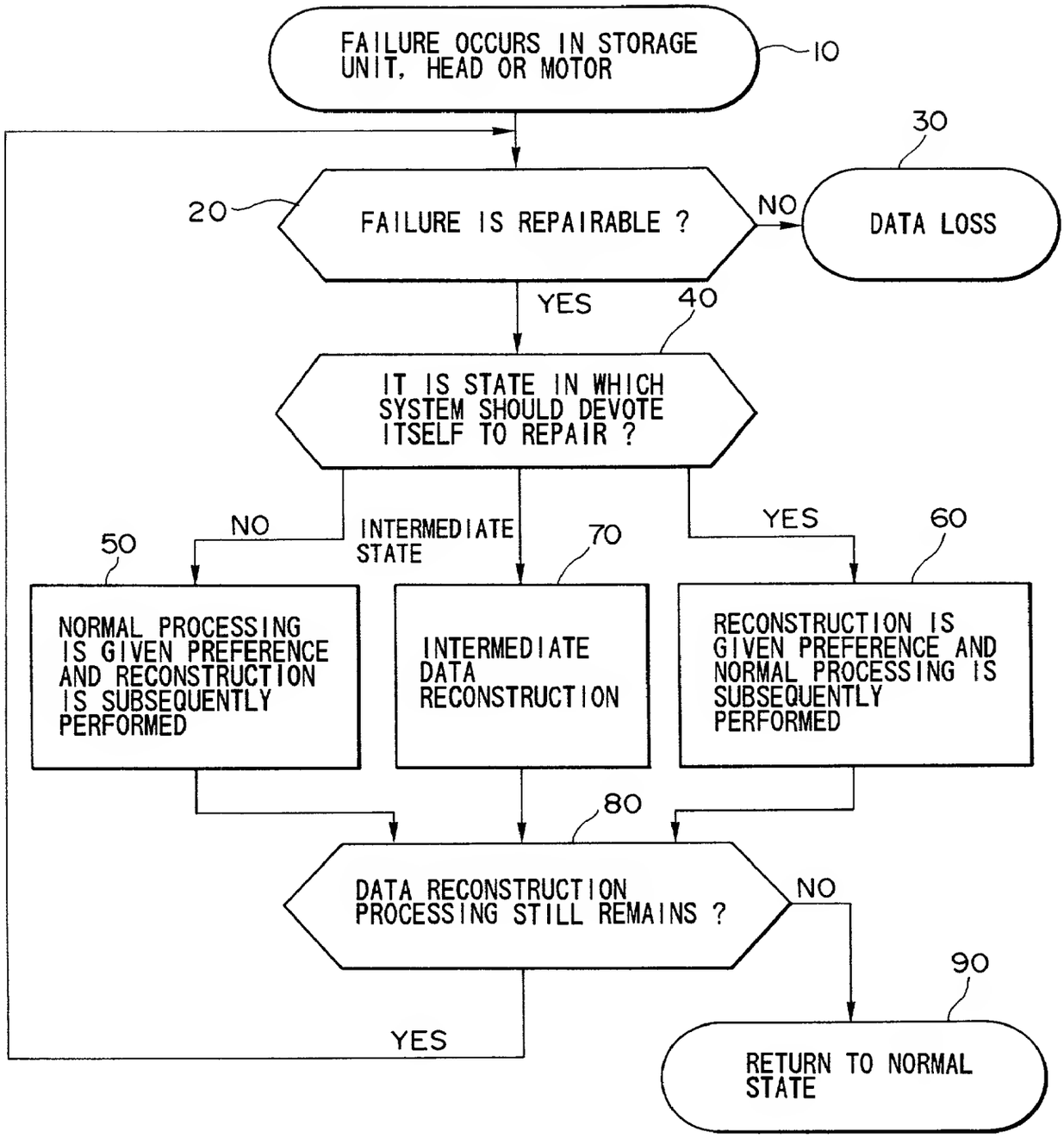

FAILURE OCCURS IN STORAGE UNIT, HEAD OR MOTOR
10
30
20
FAILURE IS REPAIRABLE ?
NO
DATA LOSS
YES
40
IT IS STATE IN WHICH SYSTEM SHOULD DEVOTE ITSELF TO REPAIR ?
NO
INTERMEDIATE STATE
YES
50
60
70
NORMAL PROCESSING IS GIVEN PREFERENCE AND RECONSTRUCTION IS SUBSEQUENTLY PERFORMED
INTERMEDIATE DATA RECONSTRUCTION
RECONSTRUCTION IS GIVEN PREFERENCE AND NORMAL PROCESSING IS SUBSEQUENTLY PERFORMED
80
DATA RECONSTRUCTION PROCESSING STILL REMAINS ?
NO
90
YES
RETURN TO NORMAL STATE

FIG.2

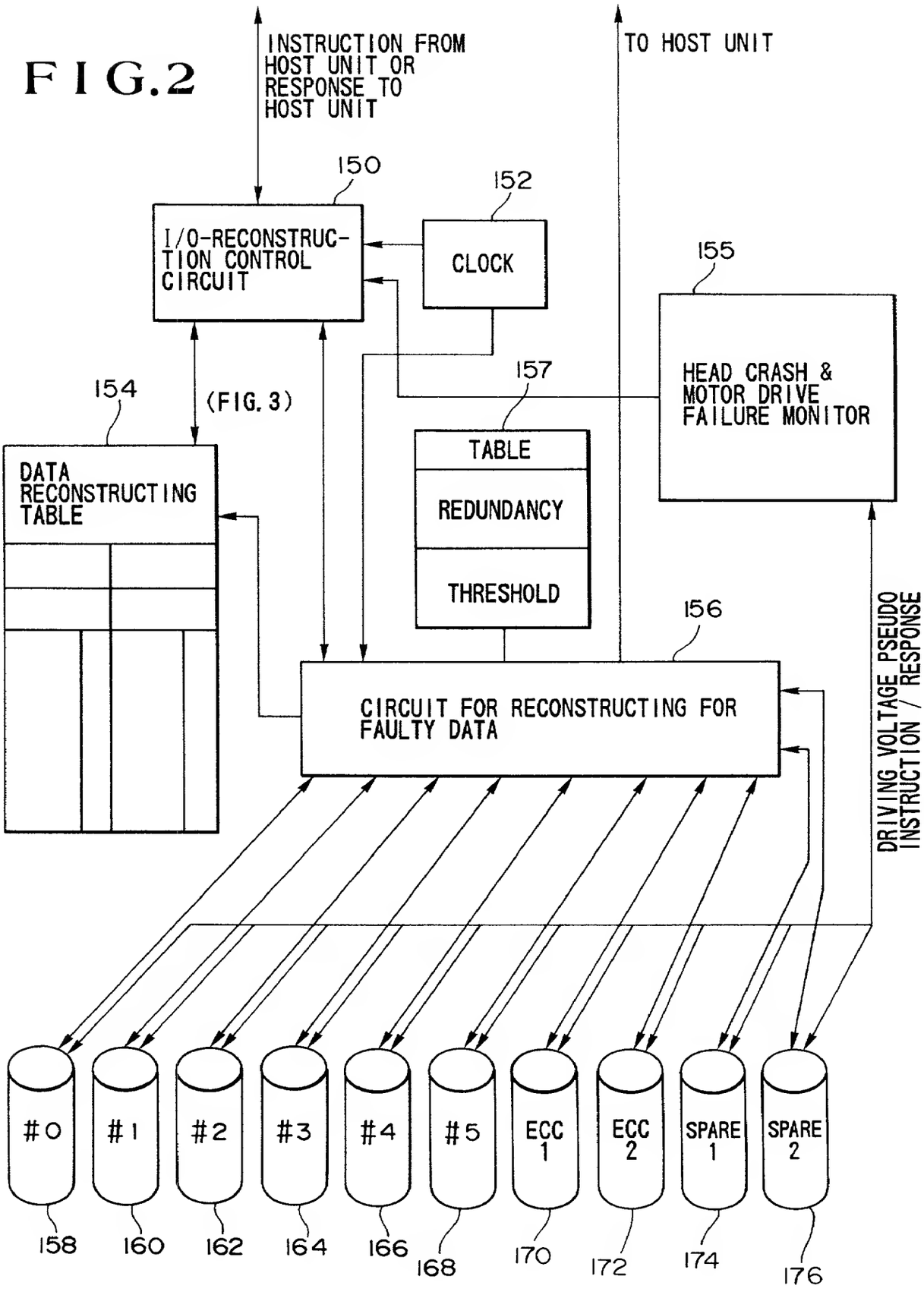

INSTRUCTION FROM HOST UNIT OR RESPONSE TO HOST UNIT
TO HOST UNIT
150
I/O-RECONSTRUCTION CONTROL CIRCUIT
152
CLOCK
155
HEAD CRASH & MOTOR DRIVE FAILURE MONITOR
157
TABLE
REDUNDANCY
THRESHOLD
154
(FIG.3)
DATA RECONSTRUCTING TABLE
156
CIRCUIT FOR RECONSTRUCTING FOR FAULTY DATA
DRIVING VOLTAGE PSEUDO INSTRUCTION / RESPONSE
#0
#1
#2
#3
#4
#5
ECC 1
ECC 2
SPARE 1
SPARE 2
158
160
162
164
166
168
170
172
174
176

FIG.3

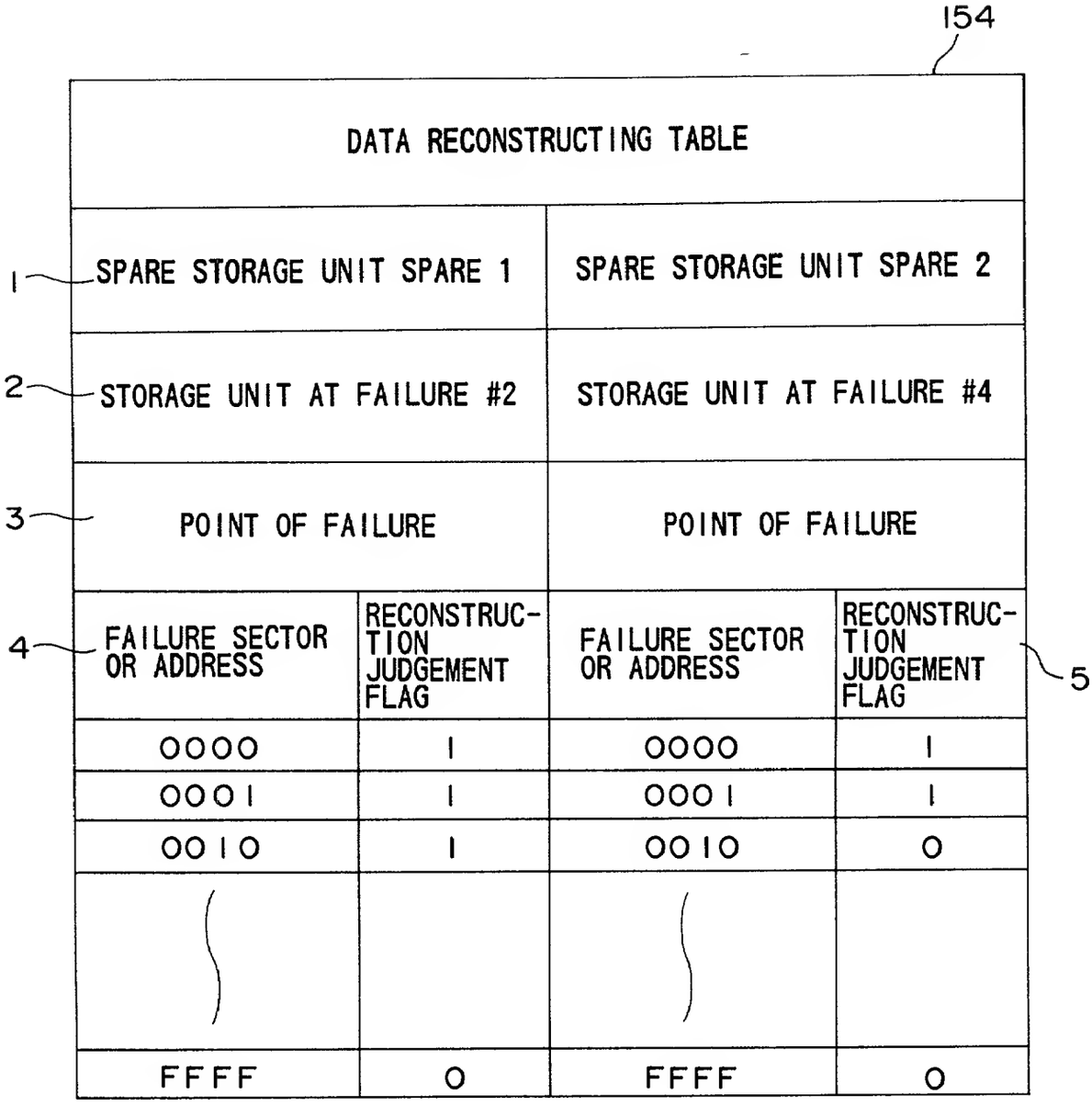

154
DATA RECONSTRUCTING TABLE
1
SPARE STORAGE UNIT SPARE 1
SPARE STORAGE UNIT SPARE 2
2
STORAGE UNIT AT FAILURE #2
STORAGE UNIT AT FAILURE #4
3
POINT OF FAILURE
POINT OF FAILURE
4
FAILURE SECTOR OR ADDRESS
RECONSTRUC-TION JUDGEMENT FLAG
FAILURE SECTOR OR ADDRESS
RECONSTRUC-TION JUDGEMENT FLAG
5
0000
1
0000
1
0001
1
0001
1
0010
1
0010
0
FFFF
0
FFFF
0

FIG.4

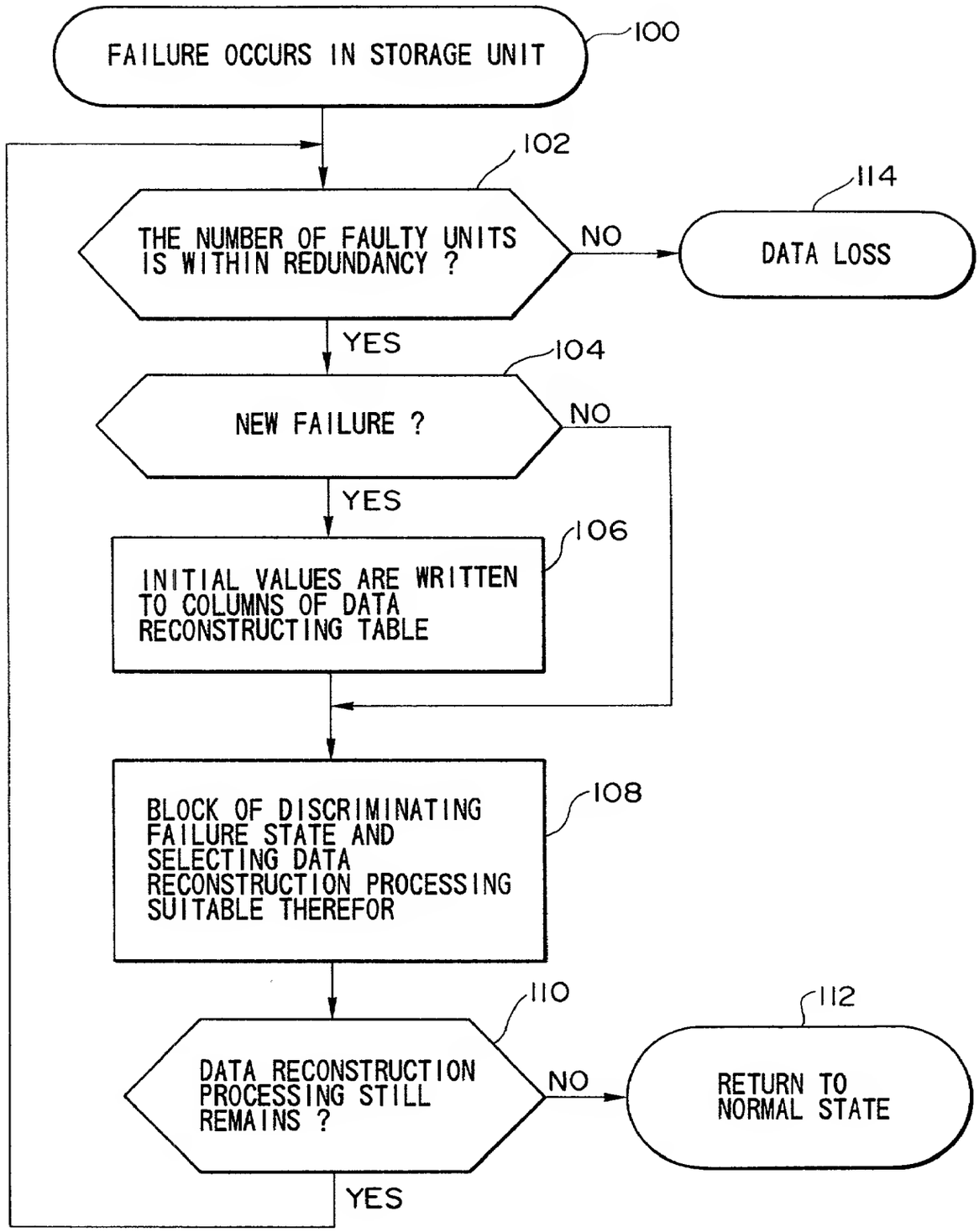

FAILURE OCCURS IN STORAGE UNIT
100
102
THE NUMBER OF FAULTY UNITS IS WITHIN REDUNDANCY ?
NO
114
DATA LOSS
YES
104
NEW FAILURE ?
NO
YES
106
INITIAL VALUES ARE WRITTEN TO COLUMNS OF DATA RECONSTRUCTING TABLE
108
BLOCK OF DISCRIMINATING FAILURE STATE AND SELECTING DATA RECONSTRUCTION PROCESSING SUITABLE THEREFOR
110
DATA RECONSTRUCTION PROCESSING STILL REMAINS ?
NO
112
RETURN TO NORMAL STATE
YES

FIG.5

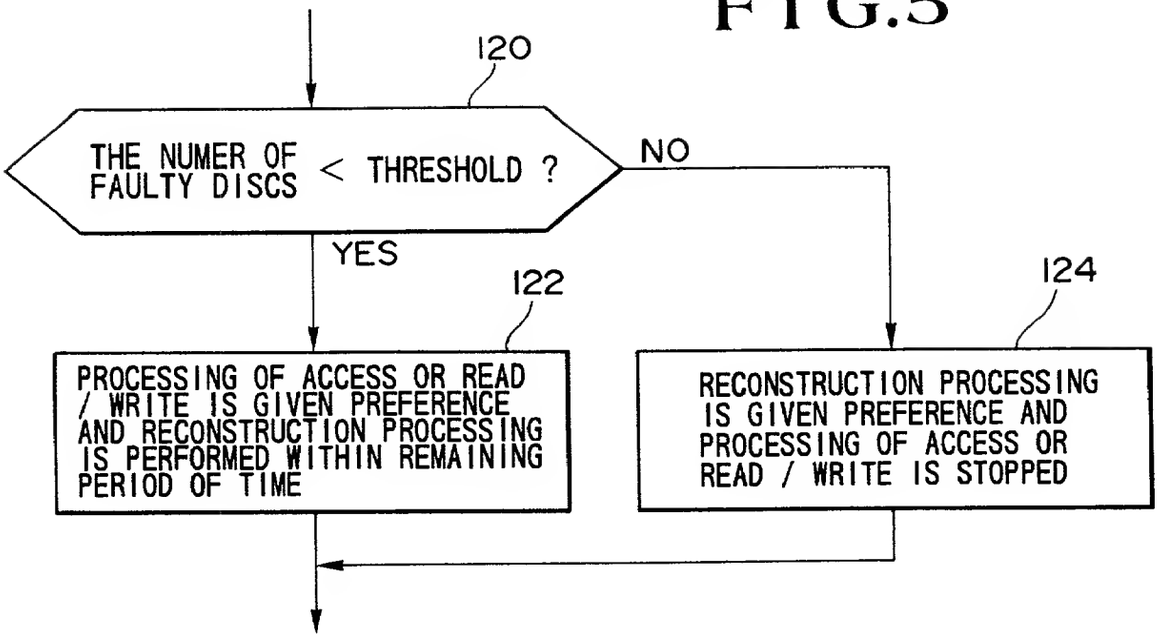

120
THE NUMER OF FAULTY DISCS < THRESHOLD ?
NO
YES
122
124
PROCESSING OF ACCESS OR READ / WRITE IS GIVEN PREFERENCE AND RECONSTRUCTION PROCESSING IS PERFORMED WITHIN REMAINING PERIOD OF TIME
RECONSTRUCTION PROCESSING IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ / WRITE IS STOPPED

FIG.6

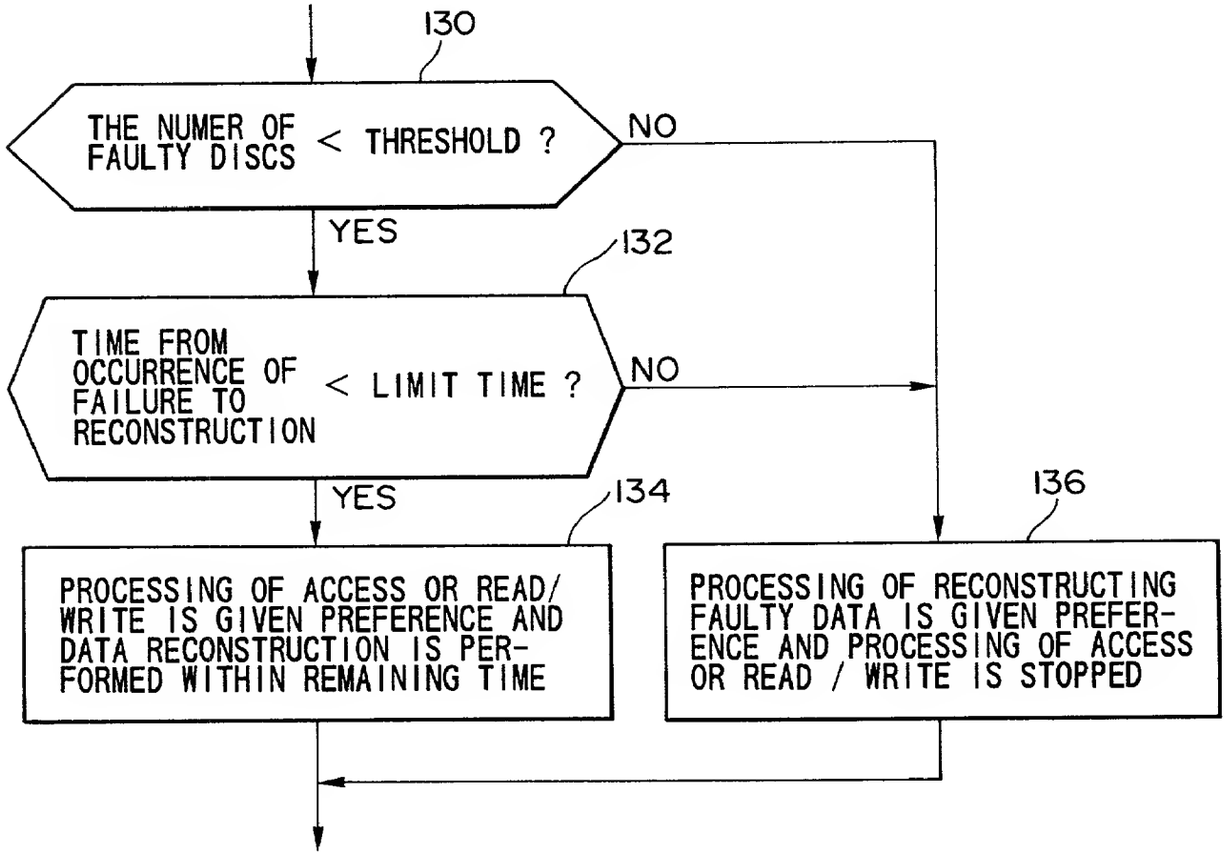

130
THE NUMER OF FAULTY DISCS < THRESHOLD ?
NO
YES
132
TIME FROM OCCURRENCE OF FAILURE TO RECONSTRUCTION < LIMIT TIME ?
NO
YES
134
136
PROCESSING OF ACCESS OR READ/ WRITE IS GIVEN PREFERENCE AND DATA RECONSTRUCTION IS PERFORMED WITHIN REMAINING TIME
PROCESSING OF RECONSTRUCTING FAULTY DATA IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ / WRITE IS STOPPED

FIG.7

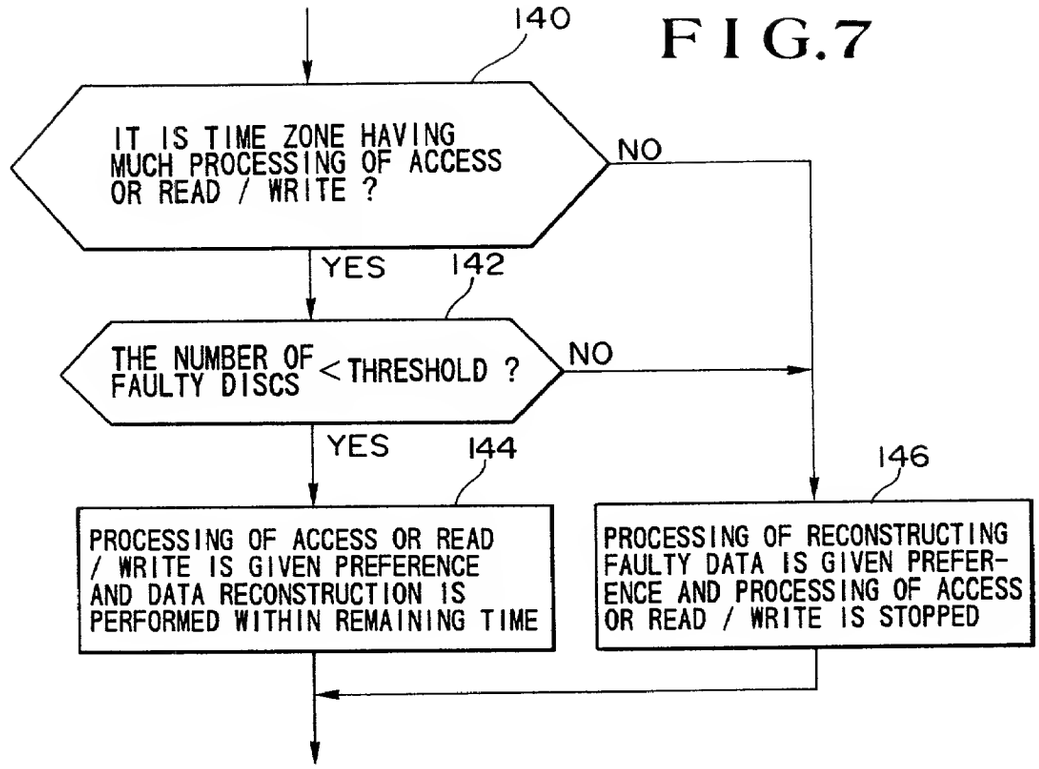

140
IT IS TIME ZONE HAVING MUCH PROCESSING OF ACCESS OR READ / WRITE ?
NO
YES
142
THE NUMBER OF FAULTY DISCS < THRESHOLD ?
NO
YES
144
PROCESSING OF ACCESS OR READ / WRITE IS GIVEN PREFERENCE AND DATA RECONSTRUCTION IS PERFORMED WITHIN REMAINING TIME
146
PROCESSING OF RECONSTRUCTING FAULTY DATA IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ / WRITE IS STOPPED

FIG.8

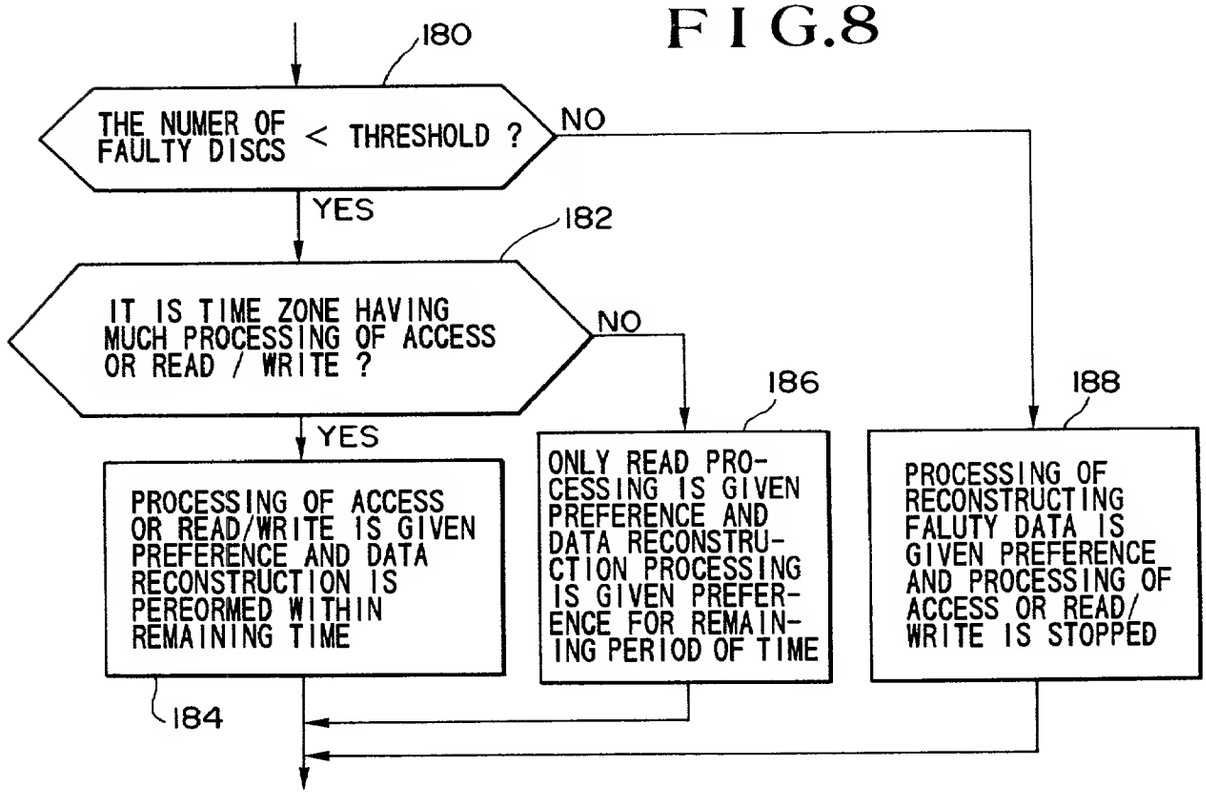
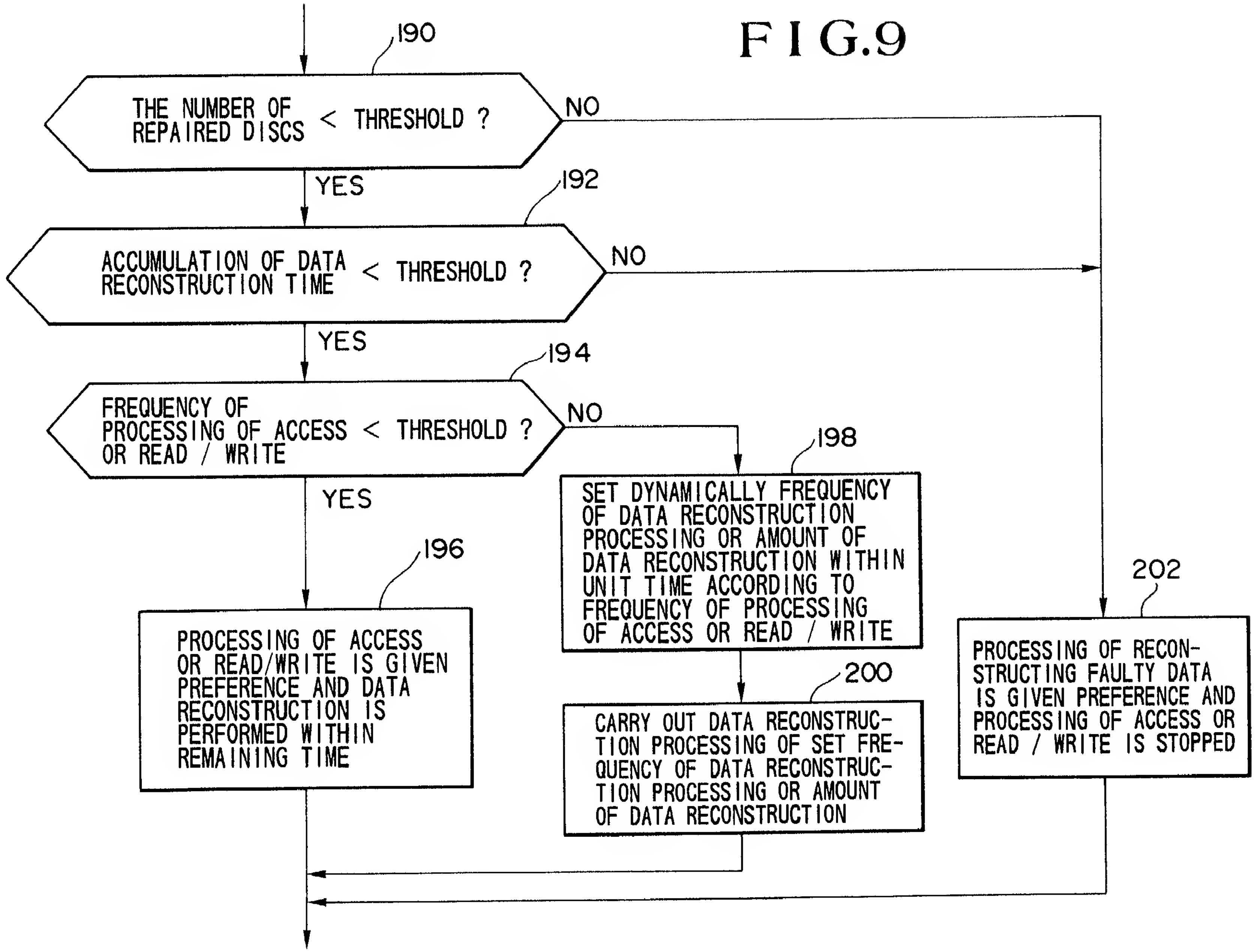

180
THE NUMER OF FAULTY DISCS < THRESHOLD ?
NO
YES
182
IT IS TIME ZONE HAVING MUCH PROCESSING OF ACCESS OR READ / WRITE ?
NO
YES
186
188
PROCESSING OF ACCESS OR READ/WRITE IS GIVEN PREFERENCE AND DATA RECONSTRUCTION IS PEREORMED WITHIN REMAINING TIME
ONLY READ PROCESSING IS GIVEN PREFERENCE AND DATA RECONSTRUCTION PROCESSING IS GIVEN PREFERENCE FOR REMAINING PERIOD OF TIME
PROCESSING OF RECONSTRUCTING FALUTY DATA IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ/ WRITE IS STOPPED
184

FIG.9



190
THE NUMBER OF REPAIRED DISCS < THRESHOLD ?
YES
NO
192
ACCUMULATION OF DATA RECONSTRUCTION TIME < THRESHOLD ?
YES
NO
194
FREQUENCY OF PROCESSING OF ACCESS OR READ / WRITE < THRESHOLD ?
YES
NO
196
PROCESSING OF ACCESS OR READ/WRITE IS GIVEN PREFERENCE AND DATA RECONSTRUCTION IS PERFORMED WITHIN REMAINING TIME
198
SET DYNAMICALLY FREQUENCY OF DATA RECONSTRUCTION PROCESSING OR AMOUNT OF DATA RECONSTRUCTION WITHIN UNIT TIME ACCORDING TO FREQUENCY OF PROCESSING OF ACCESS OR READ / WRITE
200
CARRY OUT DATA RECONSTRUCTION PROCESSING OF SET FREQUENCY OF DATA RECONSTRUCTION PROCESSING OR AMOUNT OF DATA RECONSTRUCTION
202
PROCESSING OF RECONSTRUCTING FAULTY DATA IS GIVEN PREFERENCE AND PROCESSING OF ACCESS OR READ / WRITE IS STOPPED

18443-01

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COMBINED DECLARATION AND POWER OF ATTORNEY
(宣誓書及び委任状)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"DATA RECONSTRUCTION METHOD AND SYSTEM EMPLOYING THE SAME"

the specification of which: (check one) ☒ is attached hereto.

☐ was filed on _____
as Application Serial No. _____
and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
03-094728 (Number)	Japan (Country)	1 April, 1991 (Day/Month/Year Filed)	☒ Yes	☐ No
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐ Yes	☐ No
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐ Yes	☐ No

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to discolse to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international fiiling date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
_____	_____	_____
_____	_____	_____

(Continued on Page 2)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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